POWER PLANT ENGINEERING

Established Over 34 Years

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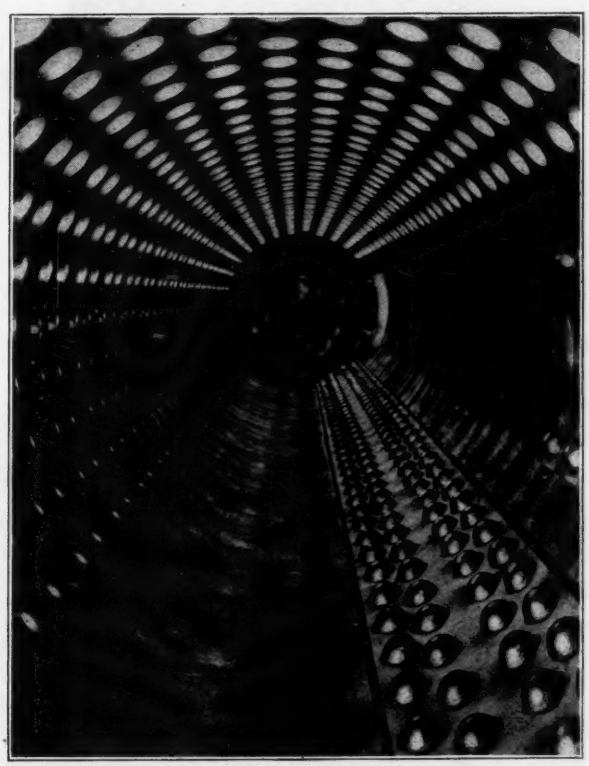


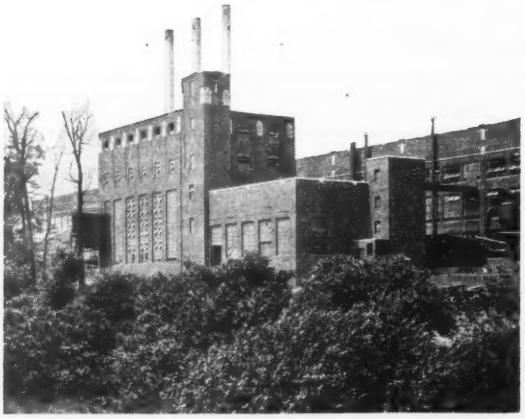
Up in the Air

IN SPITE OF a few perverse individuals who still think that aviation is hazardous, not as bad as pedestrianism, to be sure, but still risky, to say nothing of being expensive, the country is rapidly becoming air-minded. Artistic lighting effects, aeroplane beacons and air mail are all having their effect.

So much so, in fact, that the photographer at the Erie City Iron Works could not miss the celestial appearance of an aesthetic boiler drum. Of course any engineer can appreciate the artistry of Erie City workmanship but to make a realistic Aurora Borealis from a few holes in a piece of boiler plate is just a step in advance of the artistic requirements of industry.

In fact, this matter of holes is keeping many engineers up in the air. For instance, the fineness of pulverized coal is measured by holes or openings in sieves. Some of these individuals get all hot and bothered about the apparent lack of uniformity between different sieve series and to bring these people down to earth we have reviewed the matter on page 1220. After all, whether we say U. S. No. 50 or Tyler No. 48 is relatively unimportant when compared with differences that may creep in from improper sieving methods or tolerances in openings.

Steam and Power for Atwater Kent



Modern pulverized coal plant supplies steam, power from back-pressure turbine supplemented by purchased power, to great industrial plant making radio apparatus. Evaporators furnish pure water for boiler feed make-up and supply steam for feedwater heating in summer and for building heating in winter

TO SUPPLY HEATING and process steam to its great radio manufacturing plant in Philadelphia, the Atwater Kent Manufacturing Co. has recently put in operation a new power house that incorporates many interesting engineering features of the most modern type. Three steam generating units, equipped with water walls in four sides of the furnaces and with superheaters, supply steam at 200 lb. and 100 deg. superheat. The furnaces are fired by pulverized coal supplied by unit pulverizers on the boiler room floor. Heated air is supplied from air preheater located in back and part of the boiler setting. Each steam unit is equipped with a dust collector to reduce the amount of fly-ash leaving the stacks and to insure cleanliness of the plant and surrounding atmosphere. For purification of the boiler feedwater, double effect evaporators were installed. In winter the steam made by these evaporators is sent out into the heating system and condensed. In summer when the feedwater heater cannot take care of the steam, a surface condenser is cut in.

Coal is dropped from cars on the siding at side of power house, into a hopper and carried by conveyor to a crusher whence it is elevated to a 520-t. coal bunker under the roof. Coal is fed by spouts to automatic scales above the pulverizer. The scales are on tracks so that they can be moved from one boiler to the other.

Ash as well as the dust from the back connection of the boiler, from the preheater and from fly-ash collectors is handled entirely by a sluicing system discharging into an ash storage tank outside above the coal track. Because of the necessity of using metered water, the water of this system is recirculated.

In winter the heating load will run up to 3000 b.hp. with a process steam load of another 1000 b.hp., the process steam going out to the factory at about 45 lb. To take advantage of the difference between this pressure and the boiler pressure, a back pressure turbine generator was installed. This unit is floated with the Philadelphia Electric Co. service and is automatically governed both as to electrical and steam demand. It is expected to just about handle the process steam in summer.

Plant Designed for Convenience as Well as Economy

In designing this plant for Atwater Kent Manufacturing Co., every care was taken to secure economy in operation combined with convenience and simplicity. To secure proper records of operation at all times, a centralized control board was placed in the office of the chief operating engineer, where he can observe at a glance the various pressures and temperatures being maintained and the amounts of steam and power going to all departments of the factory. Each boiler is equipped with a complete control board for the operation of that boiler.

To provide the best possible working conditions for the employes, shower baths and locker rooms are conveniently arranged on the main power house floor between boiler and turbine rooms. There is a space for the men to eat lunch, provided with an electric refrigerator, an electric stove and comfortable tables and chairs.

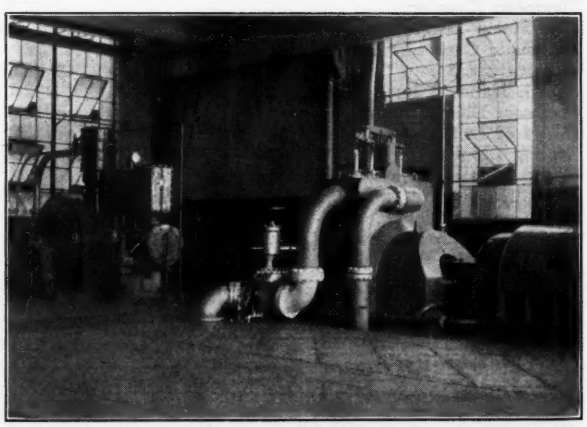


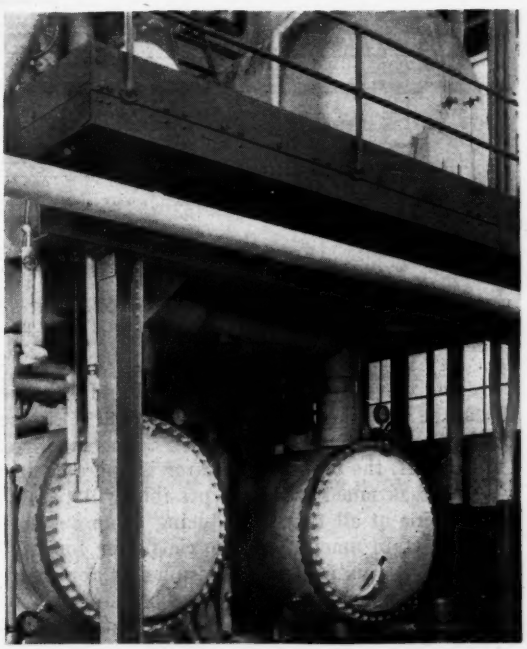
FIG. 1. BACK-PRESSURE TURBINE-GENERATOR AND ANGLE-COMPOUND AIR COMPRESSOR

The power plant building itself is an attractive, simple design, constructed of red brick and steel with stone trim and large windows in all four walls. Inside the building, liberal use of white and aluminum paint makes the boiler room pleasant to work in, with plenty of light and space around each piece of equipment. The contents and direction of flow in piping are indicated by a system of colored arrows on the pipe, the A.S.M.E. color code being used as a base.

With this general picture of the Atwater Kent power plant in mind, let us turn to some of the details of its outstanding features. One of these is the method of using the evaporators to meet the different conditions of summer and winter loads.

Details of Evaporator Operation

Figure 5 shows the heat balance diagram for summer operation and Fig. 8 for winter operation. In the summer, when no steam is needed in the heating systems of the factory, the evaporators operate as a double effect or as two single-effect units, as conditions call for, the steam generated being used for feedwater heating in the deaerating heater or being condensed in a surface condenser. During cold weather, when the demand for factory heating steam is large, the evaporators operate as one single-effect unit, discharging steam at 15 lb. gage from the second effect into the heating mains.



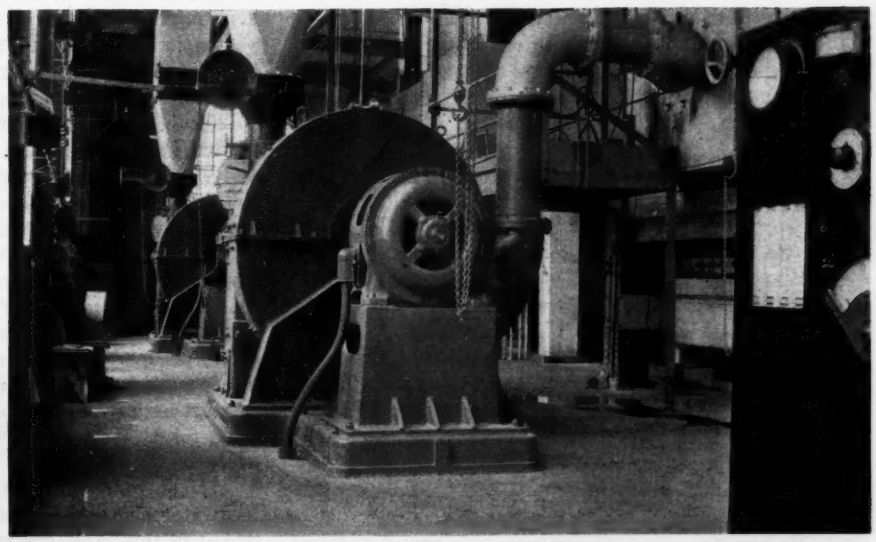
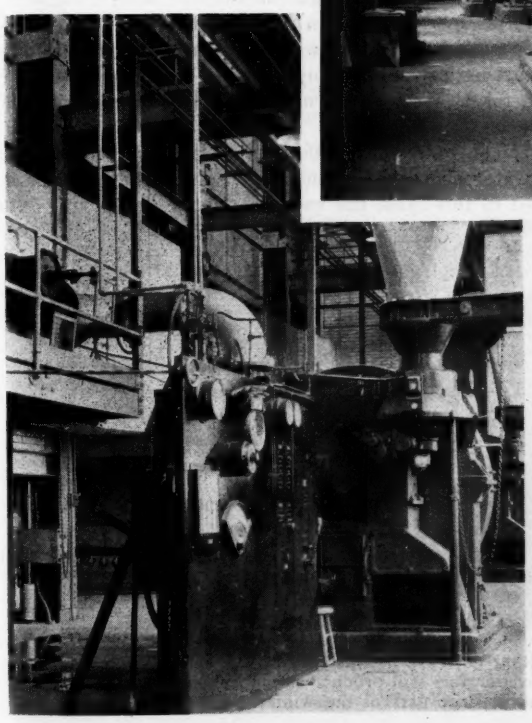


FIG. 2. TWO 370-SQ. FT. EVAPORATORS, WITH EVAPORATOR CONDENSER AND DEAERATING HEATER OVERHEAD

FIG. 3. GENERAL VIEW OF TWO BOILER FRONTS AND PULVERIZERS

FIG. 4. ONE OF THE BOILERS AND PULVERIZERS SHOWING BOILER CONTROL PANEL



Steam for both process work and heating leaves the power house at about 45 lb. gage pressure, through a 14-in. line. The turbine generator exhausts into this line and will automatically supply steam to it up to the capacity of the machine or electric load. If the turbine should not be able to supply the required amount of steam, as in winter, a reducing valve cuts in and feeds in the required amount of steam from the 200-lb. lines. As a guide to the chief engineer, a set of signal lights in his office show the amount this reducing valve is open.

Evaporators are also operated from the 45-lb. line normally and in winter discharge into a line running into the factory heating system back of the secondary

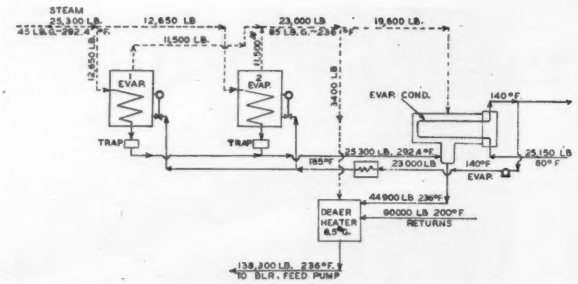


FIG. 5. HEAT BALANCE OF EVAPORATORS FOR SUMMER OPERATION, WHEN EVAPORATOR STEAM HEATS FEEDWATER

reducing valves, which are set at 15 lb. In summer they discharge into the feedwater heater and a surface condenser.

In brief, the turbine-generator is operated in such a way that as much steam as possible will pass through the turbine at all times, producing at an extremely low cost a certain amount of electric power for use in the factory. If this power is not sufficient for the demand it is supplemented by the purchased power, while if the amount of steam at full load is not enough for the

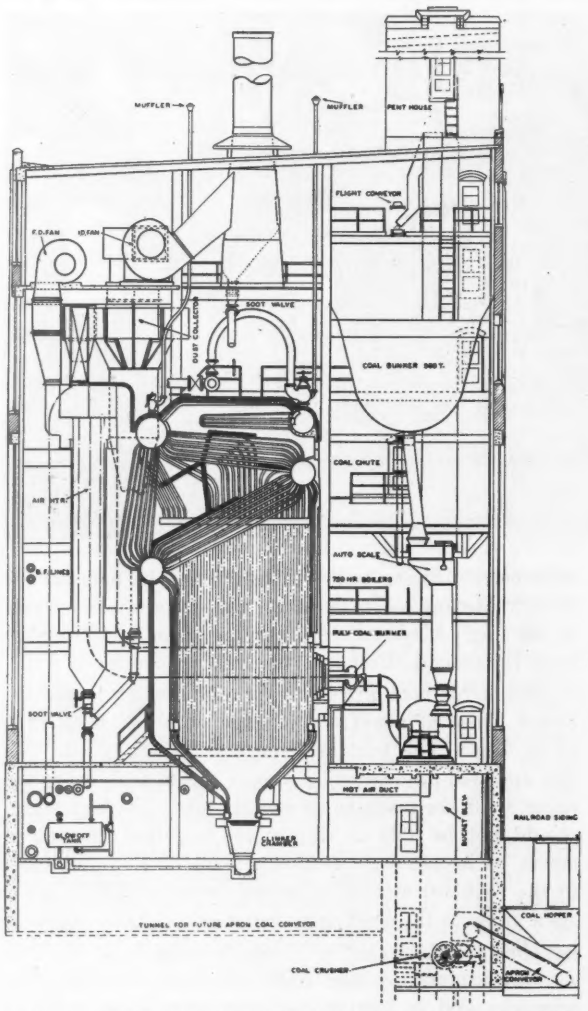


FIG. 6. GENERAL CROSS-SECTION THROUGH BOILER ROOM

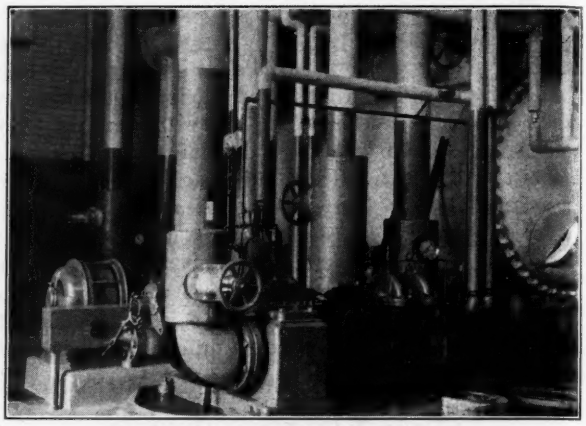


FIG. 7. MOTOR-DRIVEN AND TURBINE DRIVEN BOILER FEED PUMPS IN FRONT OF EVAPORATORS

evaporators and processes in summer or for the processes in winter, the deficiency is made up by live steam through the reducing valves.

Evaporators and Feedwater Heater

The evaporators are two 370-sq. ft. high-pressure, horizontal submerged type units, located on the main power house floor, with the boiler feed pumps in front of them, as shown in Fig. 2. The units are designed to distill 26,000 lb. of water an hour with steam pressure of 200 lb. to the first effect. Evaporator shells are of welded steel plate, designed for 75 lb. pressure; coils and headers are designed for a working pressure of 250 lb. Each evaporator shell has two steam outlets and two gill type steam purifiers.

On the balcony over the evaporators are the evaporator condenser and deaerating feedwater heater. This heater is designed to heat feedwater to about 250 deg. F. Its method of operation in conjunction with the evaporators is clearly shown in Figs. 5 and 8. To save distilled water when the heating system is unbalanced, as in starting up or shutting down, a 15,000-gal. storage tank takes excess returns from heating system and processes.

A 3000-gal. storage tank is part of the deaerating feedwater heater. Practically a constant level is maintained in this tank, the vacuum pumps discharging into

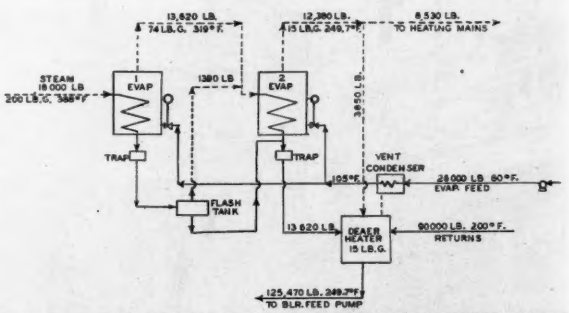


FIG. 8. HEAT BALANCE OF EVAPORATORS FOR WINTER OPERATION SHOWING DOUBLE-EFFECT EVAPORATION DISCHARGING STEAM TO HEATING MAINS

This shows extreme conditions with 200 lb. steam going to evaporators. Because of improvements in processes and resulting decrease in waste of return, it has been found that the evaporators will produce enough makeup with 45-lb. steam during a large part of the winter.

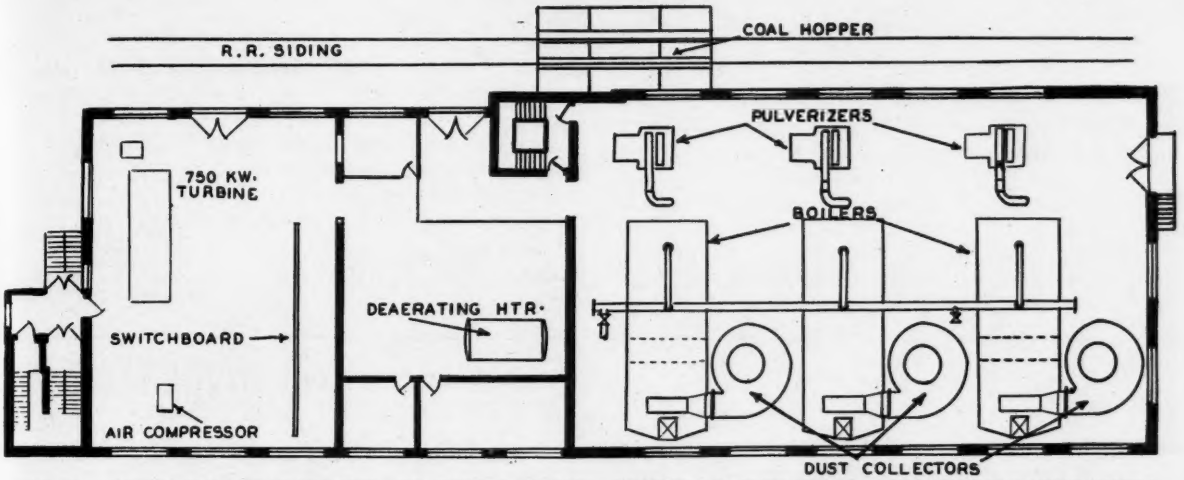


FIG. 9. GENERAL ARRANGEMENT OF POWER PLANT SHOWING BOILER ROOM AND TURBINE ROOM LAYOUT

it from the return lines. When the high level is reached a valve automatically opens and diverts the returns into the 15,000-gal. storage tank. This relieves the vacuum pumps from having to put the excess water up into the heater to overflow back to the storage tank. Floats operating Mercoid switches also operate a centrifugal pump which maintains the water level in the heater from the 15,000-gal. tank when the returns are not sufficient to do so.

Three steam generating units, as shown in Figs. 4 and 6 supply steam at 200 lb. gage, about 488 deg. total steam temperature. Each of these units is supplied as a complete steam generator by the manufacturer, each including boiler heating surface of 7203 sq. ft., superheater of 950 sq. ft., furnace water wall heating surface of 4124 sq. ft. and air heater surface of 11,250 sq. ft. All tubes in these boilers are coated inside with a special protective coating designed to prevent corrosion and this precaution, together with the use of evaporated makeup water, is expected to insure the utmost freedom from internal boiler troubles.

Water-Cooled Furnaces Are Fired with Pulverized Coal

Furnaces are completely water-cooled as shown, except for the small space around the pulverized coal burners. Bare 3¼-in. tubes are used, set on 4¼-in. centers, backed up by flat tile and plastic refractory. The entire boiler is covered with steel panels to provide easy access and good appearance.

In front of each boiler stands the unit pulverizer designed to supply a maximum of 7500 lb. of pulverized coal an hour to each furnace. Coal is fired by a single turbulent type burner in the front wall. Of the air for combustion, 20 per cent is supplied to the pulverizer for coal drying and carrying air, the remainder going to the burner as secondary air. The air goes to pulverizer and burner at about 350 deg.

Fuel burned at present in the plant is Pennsylvania coal and coke, averaging 14,400 B.t.u. per lb. dry and about 27 per cent volatile.

On each boiler a forced draft fan of 91,500 lb. an hour maximum capacity supplies air through the air preheater. Induced draft is furnished by a fan of 103,800 lb. of gas an hour maximum capacity; the boiler gas leaving the preheater passes through dust collectors, installed as shown in Fig. 6, before going to the induced draft fan. Disposal of dust from the collectors, stack hopper, air preheater and last pass is by means of dust valves that sluice it to the ash disposal system as described above.

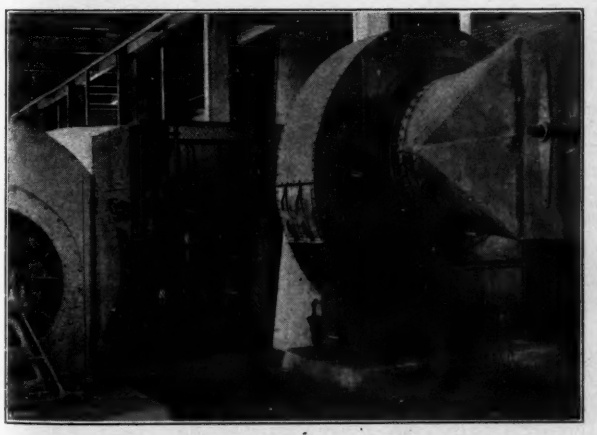


FIG. 10. INDUCED DRAFT FAN FOR ONE BOILER (AT RIGHT) FORCED DRAFT FAN (AT LEFT) AND MOTOR CONTROL PANELS (BACKGROUND)

FIG. 11. SWITCHBOARD AND DISTRIBUTION PANELS IN TURBINE ROOM

Details of Central and Boiler Control Boards

Provisions for convenience and accuracy of control in the Atwater Kent power plant are most complete. Each boiler and its auxiliaries are operated from a control board near the unit pulverizer. The main steam lines run from non-return valves at the boiler through U-bends to motor-operated valves at the main header, these valves being controlled from the boiler control panel. This panel carries a remote boiler water level indicator, an indicating pyrometer for furnace, flue gas and air temperatures; draft gages; indicating steam flow meter; pressure gage and controls for fans and pulverizer and CO_2 meter. Fans are operated by push button control; the motor controllers installed on the fan floor provide 23 speed steps on the variable speed motors. The fan motors and pulverizer motors are all interlocked so that in starting, the induced draft fan must be started first, then the forced draft fan and finally the pulverizer, the sequence being reversed when shutting down. Dampers are controlled by hand through a special arrangement of levers near the boiler panel.

In the chief engineer's office, a panel carries steam flow meters for recording output of each boiler, indicating and recording gages for boiler steam pressure, heating system pressure, turbine exhaust pressure and evaporator discharge pressure. Other indicating gages show city water pressure, air pressure and heating system pressure in Bldg. 7. Pyrometers record temperatures in furnace, superheater pass, back pass, stack and air preheater outlet for each boiler. A venturi meter measures feedwater going to each boiler.

Data on Performance of Steam Generating Units

Performance of the above steam generating units is, after all, the most important thing about them and recent tests have indicated that they have met their guarantees successfully. These guarantees, on which they were designed, are as follows:

Output per boiler, lb. steam per hr.	26,000	60,000	82,000
Boiler horsepower	840	1940	2650
Gas leaving boiler, deg. F.	490	580	650
Gas leaving preheater, deg. F.	220	250	320
Air leaving preheater, deg. F.	400	430	410
(Above temperature based on 70 deg., room temp.)			
Efficiency of unit, per cent	86	86	82
Coal fired per hour	2330	5380	7710
Flue gas, lb. per hr.	31,400	72,500	103,800
Air through preheater, lb. per hr. (95% of total for combustion)	27,700	63,900	91,500
B.t.u. liberated in furnace per hr. (loss due to unburned carbon—1.5%)	32,100,000	74,100,000	106,200,000
B.t.u. liberated per cu. ft. furnace volume	5580	12,900	18,500

Principal Power Plant Equipment at Atwater Kent Mfg. Co.

General

Location .....Philadelphia, Pa.
Service .....Industrial heating, process steam, electric power
Total steam capacity, max. .....246,000 lb. an hr.
Power capacity .....750 kw., 0.5 p.f.; 1000 kw., 0.9 p.f.
Architects and engineers. The Ballinger Co.
Building contractor.....Wm. Steel & Sons

Boilers and Coal Burning Equipment

3 Badenhausen Corp. steam generating units, each with 7203 sq. ft. boiler heating surface; 4124 sq. ft. furnace water wall heating surface; 950 sq. ft. superheating surface; 11,250 sq. ft. air preheater heating surface; 5750 cu. ft. of furnace volume. Designed for 200 lb. gage working pressure, 100 deg. F. superheat or about 488 deg. total steam temperature; 212 deg. feedwater temperature, 70 deg. F. room temperature, 14 per cent CO_2, coal of 14,000 B.t.u. per lb. Designed for output per boiler of 26,000 lb. steam an hour minimum, 60,000 lb. an hour normal and 82,000 lb. an hour maximum. All tubes and drums protected by Dampney Co. of America's Apexior.
Feedwater regulators, differential type (Copes).....Northern Equipment Co.
Soot blowers.....Vulcan Soot Cleaner Co.
Water columns, Yarway with Sesure gage glasses.....Yarnall-Waring Co.
Blowoff valves.....Yarnall-Waring Co.
3 Boiler control boards, 1 per boiler, each carrying Foxboro remote feedwater level indicator, Brown pyrometer, Ellison draft gages, Hays CO_2 recorders, Bailey indicating flow meters, controls for auxiliary motors.
3 Riley Stoker Corp. Atritas (1 per boiler) each designed for pulverizing 7500 lb. coal an hour, driven by 2300-v. Crocker-Wheeler motor.
3 Riley Stoker Corp. turbulent pulverized coal burners, (1 per boiler) capacity each 7500 lb. coal an hour. Forced draft type.

Coal and Ash Handling Equipment

Coal handling equipment all supplied by Link-Belt Co. Capacity 50 t. an hour. Apron conveyor, crusher, bucket elevator, flight conveyor, hoppers, chutes and accessories.
2 Automatic coal scales traveling across 3 boilers.....Richardson Scale Co.
Ash handling equipment all furnished by Allen-Sherman-Hoff Co. hydro-jet ash handling system, comprising sluice, 1 clear water pump and 1 ash pump, both vertical A-S-H pumps driven by G.E. motors, 50-t. overhead ash storage bunker, piping and accessories. System includes A-S-H soot valves and connections for handling discharge from dust collectors to sluice, from back pass of boiler and from air preheater.

Fans and Draft Equipment

3 Buffalo Forge Co. Duplex Conoidal forced draft fans, 1 per boiler, max. capacity 91,500 lb. air an hour, driven by Crocker-Wheeler slip-ring motors, Westinghouse motor controls.
3 Buffalo Forge Co. Conoidal induced draft fans, 1 per boiler, maximum capacity 103,800 lb. gas an hour each. Driven by Crocker-Wheeler slip-ring motors. Westinghouse motor controls.
3 American Blower Co. Sirocco dust collectors, designed to remove from flue gas all material coarser than 200 mesh.
3 Philadelphia Boiler Works steel stacks, 1 per boiler, diameter 5 ft., height 75 ft. above steel work.

Miscellaneous

Piping.....Walter Muench Co.
Valves—
High-pressure steam .....Walworth Co., Edward Valve & Mfg. Co.
Non-return and stop valves.....Edward Valve & Mfg. Co.
Other high-pressure steam valves.....Walworth Co.
High-pressure water.....Walworth Co.
Boiler feed line.....Walworth Co.
Low-pressure steam and water.....Walworth Co.
Motor-operators for main steam valves (Dean Control). Cutler-Hammer, Inc.
Subway grating.....Irving Iron Works
Boiler insulation..The Philip Carey Co.
Safety valves .....Consolidated, Ashcroft Hancock Co.
Centralized control board—Bailey Meter Co., steam flow meters; Hays CO_2 recorders, Foxboro Co. indicating and recording meters, Brown Instrument Co. pyrometer. Builders Iron Foundry venturi meters.
Pressure reducing and regulating valves .....Atwood & Morrill Co.
Steam traps .....Cochrane Corp. and Armstrong Machine Works

Pumps and Feedwater Equipment

4 Skidmore Corp. vacuum pumps; 2 motor-driven, 2 turbine-driven pumps.
1 Dayton-Dowd Co. fire pump, 1500 g.p.m. at 100 lb. pressure, driven by Westinghouse motor.
3 Warren Steam Pump Co., Inc., centrifugal pumps, 100 g.p.m. each, driven by Crocker-Wheeler 220-v. motors; 1 for evaporators, 1 for feedwater heater storage tank, 1 reserve for either.
3 Warren Steam Pump Co. centrifugal boiler feed pumps, each 2 stage, 180 g.p.m., against 200 lb., 1 driven by Westinghouse 50-hp., 3500-r.p.m. steam turbine, 2 driven by G.E. induction motors.
1 Cochrane Corp. deaerating feedwater heater, capacity about 140,000 lb. an hour to heat feed water to about 250 deg. F.
2 Foster Wheeler Corp. horizontal, submerged type evaporators, 370 sq. ft. heating surface, each, with evaporator condenser, to be operated 1 or 2 effect for summer or winter conditions. Capacity 26,000 lb. an hour with steam at 200 lb. to first effect.

Turbine Room Equipment

1 Westinghouse Elec. & Mfg. Co. back pressure turbine, 750 kw., 0.50 power factor, 2300-v., 2 phase, 60 cycle. Steam conditions 200 lb. gage throttle pressure, 45 lb. back pressure, automatic control. Direct connected exciter.
Generator air washer (Mid-West).....American Air Filter Co., Inc.
1 Sullivan Machinery Co. angle-compound air compressor 600 c.f.m. capacity at 100 lb., with Andale aftercooler, driven by G. E. 150-hp. 2300-v. synchronous motor.
1 General Electric Co. motor-generator set for excitation of air compressor synchronous motor, 6-kw., 125 v.
1 Westinghouse Electric & Mfg. Co. switchboard with automatic controls to put turbine on line.
Motor starters, etc. .....Westinghouse Elec. & Mfg. Co.
Turbine oil purifying system.....De Laval Separator Co.

FIG. 12. BOTTOM SECTIONS OF DUST COLLECTOR, SHOWING FEED PLATE AND DUST VALVE AT DISCHARGE

Coal was to be of 14,000 B.t.u., ½—2 per cent sulphur, 1—3 per cent moisture, 16—22 per cent volatile, 70—76 per cent fixed carbon, 3—8 per cent ash.

During the heating season about 3000 b.hp. are required for the heating system and about 1000 b.hp. for process steam, which constitutes a year round demand. Evaporators and other auxiliaries are designed for taking care of a fourth boiler when it becomes necessary to add it. The plant was planned to serve an industrial development covering 8 acres.

Electric Power Distribution

Purchased power is brought to a substation at 13,200 v. from the 3-phase system of the Philadelphia Electric Co. Transformers step it down to 2300 v. and the turbine-generator, making power at this voltage, floats on the 2300-v. side of the line. Motors of over 40 hp. in the power house operate at 2300 v. and a three-wire system distributes power to them and to the transformer room through the factory. All other motors operate at 220 v. from a two-phase four-wire system running through the plant. Distribution for the 2300-v. circuits of building No. 6 is from the main switchboard in the turbine room. Here also are remote controls for the circuit breakers on the incoming power lines.

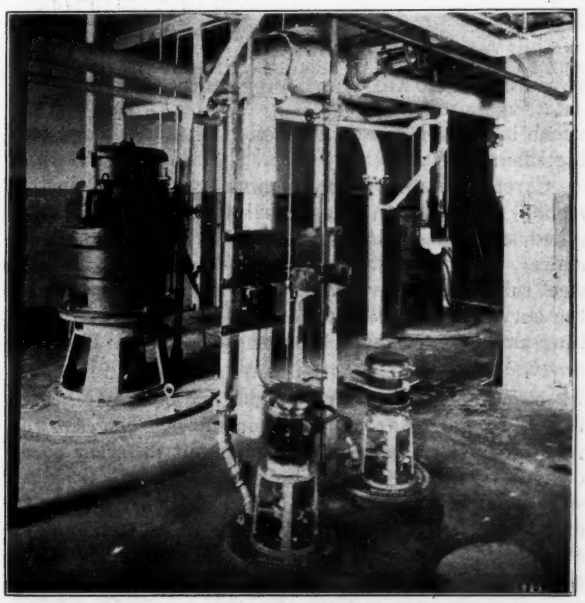


FIG. 13. PUMPS FOR THE ASH-SLUICING SYSTEM. PUMP IN FOREGROUND RECIRCULATES WATER THROUGH SYSTEM

The power plant is under the supervision of Franklin W. Gilman, plant engineer of Atwater Kent Manufacturing Co.; Robert L. Fisher is chief operating engineer. The power plant was designed by The Ballinger Co., architects and engineers of Philadelphia and New York and was erected under the supervision of R. S. Fitch, their engineer. We are indebted to both designer and owner for the heartiest coöperation in visiting the plant and securing data and photographs used in this article.

Natural Gas for Central Indiana

Central Public Service Corp. of Chicago has made final arrangements for the production of natural gas in southeastern Kentucky and is now making plans for the transporting of natural gas to central Indiana. Through one of the subsidiary companies, Central Natural Gas Corp., the corporation has contracted with the Kentucky-West Virginia Gas Co. for the operation of a large tract of gas yielding land in Kentucky, from which location the gas will be supplied to the central Indiana and other markets, according to a recent announcement by Alfred Hurlburt, vice-president, Central Natural Gas Corp.

This project has just been started. The Central Natural Gas Corp. has obtained offices in the Guaranty Bank & Trust Co. building in Lexington, Ky., for the direction of the work. Since their occupancy of these offices on August 15, gas well locations have been made in the producing area and construction plans have been started for the building of the main gas line. Actual drilling operations of a few wells were started October 1. This immediate start on the projected work is designed to fulfill the hope of the corporation to complete the main gas line and to develop a large supply of natural gas on or before January 1, 1931.

It is a large scale construction program to be finished within such a short time. Approximately 100 wells are to be drilled, and 1,500,000 ft. of 18-in. pipe are to be laid. Thousands of tons of pipe will be required for the main gas line alone, including 700 carloads of steel pipe and 80 carloads of pipe couplings. In addition to this material, at least 250,000 ft. of pipe for casing the wells will be needed. It is estimated now that the material and the labor to install it will represent an expenditure of approximately $12,000,000.

In the early days, the caloric theory of heat was generally accepted. Heat was supposed to be a definite substance with weight, which flowed from one substance to another under proper conditions. It was Joule's experiment on the mechanical equivalent of heat in 1843 that finally led to the disproval of the caloric theory. At present, the kinetic theory of heat is generally accepted.

How Do You Select Your Economizer?

CALCULATIONS FOR DETERMINING ECONOMIZER SURFACE TO GIVE BEST RESULTS FROM BOTH OPERATING AND FINANCIAL STANDPOINTS. BY THEODORE MAYNZ

CALCULATIONS INVOLVED for an economizer installation are long and complicated, involving "cut and try" methods to determine the amount of surface required to give a certain increase in boiler efficiency. The usual method of predetermining arbitrarily the temperature rise or efficiency increase desired, and then leaving the manufacturers to designate the heating surface required, is questionable practice. The temperature rise specified may be and probably is not the correct one for the conditions or installation while the surface submitted might not be the best combination of draft loss and investment to give the lowest total operating costs.

Curves and methods outlined in this paper will show how this problem can be solved, so that the minimum investment will produce the greatest benefit for any given conditions of steam requirements, operating hours, load and coal cost. Some of the curves are based on test data on one particular type of economizer so that should a different type or make be considered these curves would have to be modified, but as the methods of constructing the curves from basic data is shown, this can be easily accomplished.

The fundamental equation of economizer performance is

$$W\ (t_2 - t_1) = R \times S \times MTD \qquad I$$

where W is the water flow in lb. per hr., t_1 and t_2 is the temperature of the entering and exit water respectively, R is the coefficient of heat transmission in B.t.u. per sq. ft. per hr. per degree mean temperature difference, S is the surface in sq. ft., and MTD is the mean temp. difference between the gas and water. Calculations are simplified and results are practically identical, if R and MTD are arithmetical instead of logarithmic. Using T_1 and T_2 as the symbols for the entering and exit gas temperature and K for the ratio of the drop in gas temperature to the rise in water temperature, we can write the equation I as follows:

$$t_2 - t_1 = \frac{T_1 - t_1}{\frac{W}{R \times S} + \frac{K+1}{2}} \qquad II$$

To solve this equation we have two factors, R and K, which require experimental data. R varies with the gas mass flow while K varies with the ratio of gas to water.

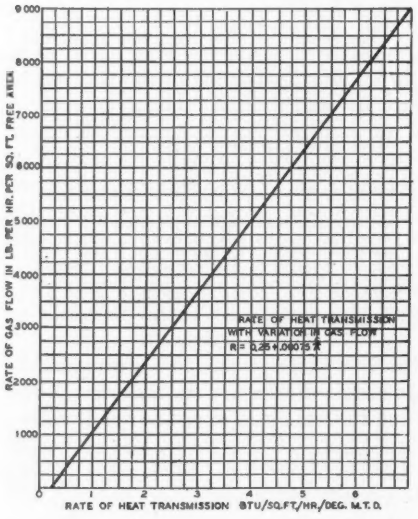

RATE OF GAS FLOW IN LB. PER HR. PER SQ. FT. FREE AREA
RATE OF HEAT TRANSMISSION BTU/SQ.FT/HR/DEG. M.T.D.
RATE OF HEAT TRANSMISSION WITH VARIATION IN GAS FLOW
R = 0.25 + .00075 G/A

FIG. 1. TEST RESULTS ON A STEEL TUBE ECONOMIZER

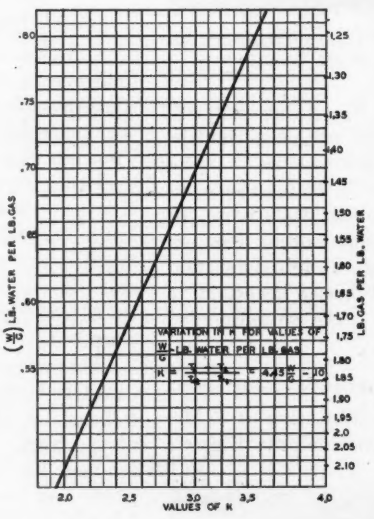


FIG. 2A. RATIO OF GAS TEMPERATURE DROP TO WATER TEMPERATURE RISE

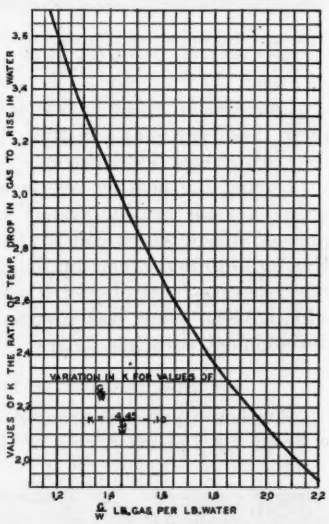


FIG. 2B. RECIPROCAL VALUES FROM FIG. 2A ARE MORE CONVENIENT TO USE

which in a given case is a function of the boiler operating efficiency.

Careful weighed water tests, using calibrated instruments, were run on two types of economizers, one a gilled steel tube and the other a cast-iron tube economizer. Values of R and K were determined. For the steel tube economizer, values of R are shown by Fig. 1, the curve having the form of $R = a + bx$, a straight line, as was expected. With the coefficients as shown

$$R = 0.25 + 0.00075\ (G \div A)$$

where $(G \div A)$ is pound of gas per hour per square foot of free area through the economizer. The cast-iron tube economizer had characteristics but different coefficients. Due to its construction the values of $(G \div A)$ were much lower, all under 3000 lb. per hr. per sq. ft. of free area. These results are from 13 tests on one and 12 tests on the other economizer. They cover the entire operating range of the installation, and the points fall on a smooth curve. Naturally this curve, Fig. 1, applies only to this type and make of economizer, a bare tube steel economizer, for one with different size tubes

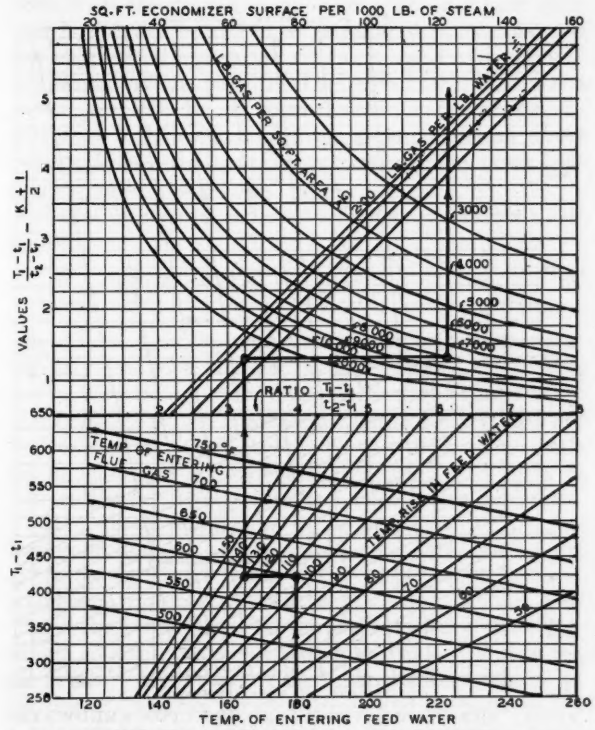

SQ. FT. ECONOMIZER SURFACE PER 1000 LB. OF STEAM
LBS. GAS PER SQ. FT. AREA
LBS. GAS PER LB. WATER
RATIO
TEMP. OF ENTERING FLUE GAS
TEMP. RISE IN FEED WATER
TEMP. OF ENTERING FEED WATER
VALUES

FIG. 3. CHART FOR CALCULATING ECONOMIZER SURFACE

or with gills would have a different curve. This economizer was standard for this make, however, and the curve can be used for calculations on all similar equipment with no appreciable error.

The constant K was also determined from these tests, and the results plotted against variation in the amount of water per pound of gas through the economizer. This gives a straight line, Fig. 2A, only one of the 25 points from both economizers, not coinciding. The equation of this curve is

$$K = 4.45\ (W \div G) - 0.10$$

For convenience in use, Fig. 2B was plotted. Here K is shown as a function of G ÷ W, the reciprocal of the first equation. It is not a straight line but has the advantage of whole numbers instead of fractions. It can be seen that K depends on the variation in gas quantity and therefore directly on the efficiency of the combustion; the greater the excess air the lower the value of K.

Calculation of Surface

For design work, we wish to know the surface required to produce a desired increase in water temperature from a known gas inlet temperature. Using 1000 lb. of water as the unit quantity, Eq. II can be written

$$S = \frac{1000}{R\left(\frac{T_1 - t_1}{t_2 - t_1}\right) - \frac{K+1}{2}} \qquad \text{III}$$

This is plotted in Fig. 3, where; the scale at the bottom of the page shows the temperature of the incoming water, t_1; the lines inclining horizontally down from left to right show the temperature of the incoming gases, T_1, therefore the scale on the lower left-hand side of the sheet shows values of the temperature difference between the incoming gas and water $(T_1 - t_1)$; the steeply inclined lines on the lower chart show the temperature rise in the water, $(t_2 - t_1)$, so that the horizontal ordinates in the middle of the sheet show the ratio of $(T_1 - t_1) \div (t_2 - t_1)$. In the upper part of the chart, the inclined straight lines show values of G ÷ W, (actually plotted in terms of (K + 1) ÷ 2 with the values of K corresponding to (G ÷ W) taken from Fig. 2B. The left-hand vertical scale of the upper part of the curve sheet gives, therefore, values of the term

$$\frac{T_1 - t_1}{t_2 - t_1} - \frac{K+1}{2}.$$

Against these values, a series of curves, showing the values of S (surface) for various values of (G ÷ A) are plotted, by using Fig. 1 to obtain R for the various values of G ÷ A.

Thus a rather complicated equation is simply solved on the two superimposed curves by substituting known design quantities for theoretical or experimental constants, for instance gas per pound of steam for K and mass gas flow per sq. ft. free area for rates of heat transmission. The free area of equipment is easily and accurately obtained from manufacturers. The use of the curve is shown by the arrowed lines, the particular conditions shown are for an entering water temperature of 180 deg. F. and entering flue gas temperature of 600 deg. F. If the desired water temperature rise is 130, and the gas to water ratio is 1.5, it is seen that a gas flow of 9000 lb. per sq. ft. free area, requires 123 sq. ft. of economizer surface per 1000 lb. of steam. If to reduce the draft loss, to slightly over 160 sq. ft.; the gas flow is lowered 7000 lb. would be required, while if the gas flow is increased to 12,000 lb. only 98 sq. ft. of surface is needed. A boiler having only 600 deg. F. exit gas tem-

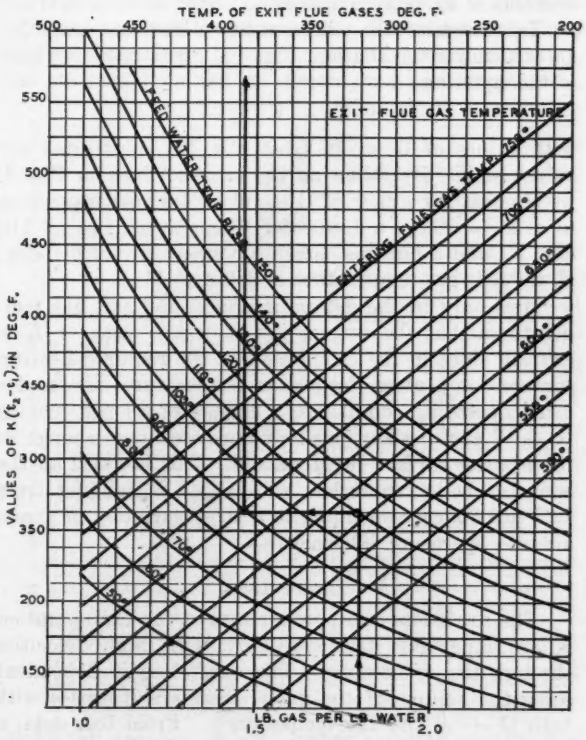

TEMP. OF EXIT FLUE GASES DEG. F.
EXIT FLUE GAS TEMPERATURE
FEED WATER TEMP. RISE
ENTERING FLUE GAS TEMP.
VALUES OF K(t₂-t₁) IN DEG. F.
LB. GAS PER LB. WATER

FIG. 4. EXIT GAS TEMPERATURES CAN BE FOUND FROM THIS CHART

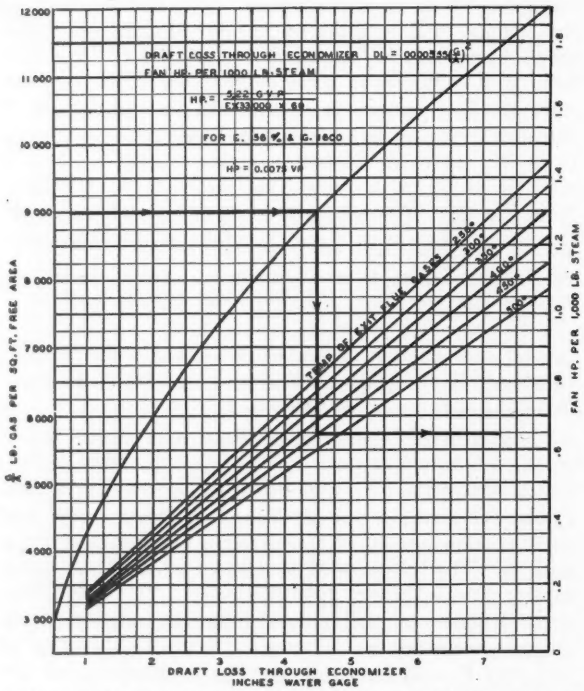

DRAFT LOSS THROUGH ECONOMIZER
FAN HP. PER 1000 LB. STEAM
FOR E. 56 % & G. 7800
HP = 0.0075 V P
TEMP OF EXIT GAS °F
DRAFT LOSS THROUGH ECONOMIZER INCHES WATER GAGE
FAN HP. PER 1,000 LB. STEAM

FIG. 5. FAN POWER AND DRAFT LOSS REQUIREMENTS ARE EASILY DETERMINED

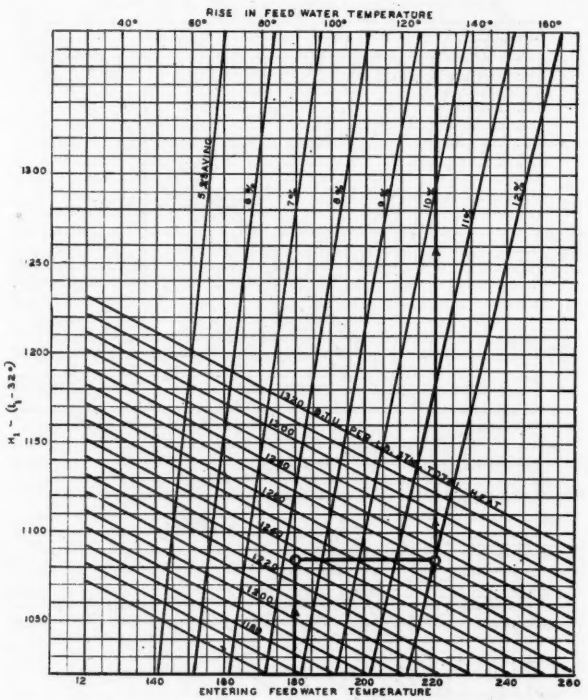


FIG. 6. PER CENT SAVINGS DEPENDS UPON FEEDWATER TEMPERATURES AND STEAM PRESSURE

perature (allowing no temperature drop between the boiler outlet and economizer inlet) is operating at about 6 lb. of steam per square foot of boiler surface, or 167 sq. ft. per 1000 lb. of steam, so that a 123-sq. ft. economizer is about 74 per cent of the boiler heating surface. A gas flow of 7000 lb. requires almost 100 per cent of economizer surface compared to boiler heating surface.

To determine the temperature of the exit gases for an economizer installation, Fig. 4 is used. This is a plot of the equation

$$T_1 - T_2 = K\,(t_2 - t_1)$$

with values of G ÷ W from Fig. 2B substituted for values of K. By following the arrowed lines on Fig. 4, we see that for a flow of G ÷ W = 1.8 (corresponding to a K = 2.38), a feedwater temperature rise of 110 deg. F., and a flue gas entering temperature of 650 deg. F. the exit gas temperature is 386 deg. F.

It is only in the determination of the exit gas temperatures that the correct gas to water ratio, or K is critical, since in the calculation of the required heating surface for a given feedwater temperature rise, under usual operating conditions, a change of 20 per cent in G ÷ W causes about one-half the percentage change in the heating surface requirements. This is based on the range of boiler operation, with G ÷ W ranging from 1.25 to 1.80, corresponding to a large variation in excess air and operating efficiency.

Draft Loss

The draft loss and power required for fan operation is an important item especially with high velocities through the economizer. The draft loss is dependent upon the volume of the gases, therefore it varies with both G ÷ A and the temperature. From test data, a curve for the draft loss through an economizer as a function of G ÷ A, was drawn, using the temperatures as found in the tests. These were the usual operating temperatures of a boiler operating from 100 to 250 per cent of rating, and are close enough to determine fan power requirements for preliminary calculations. The power requirement of a fan is

$$\text{Hp.} = \frac{5.22 \times G \times V \times P}{E \times 33{,}000 \times 60}$$

where G is pounds of gas per hour, V is the volume per pound, P is the static pressure in inches of water, and E is the static efficiency of the fan. If certain assumptions are made, this equation can be condensed considerably, and a simple expression for the fan power per 1000 lb. of steam derived. Assuming (G ÷ W) as 1.6 lb., G per 1000 lb. of steam will be 1600, and with an efficiency of 56 per cent, this equation becomes

$$\text{Hp.} = \frac{5.22 \times 1600 \times V \times P}{0.56 \times 33{,}000 \times 60}$$

and the power per 1000 lb. steam equals 0.0075 V × P. This expression is plotted in Fig. 5. By following the arrowed lines. we find that the fan power required for the economizer alone, exclusive of boiler and breeching losses, is 0.65 hp. per 1000 lb. of steam, when the gas flow (G ÷ A) is 9000 lb. and the temperature of the exit gases 300 deg. F.

Net savings due to an economizer would be the gross saving, or B.t.u. added to the boiler unit, from which the equivalent B.t.u. input of the fan power is deducted. If the fan is driven by an 85 per cent efficiency motor, and the plant can make a kilowatt-hour on 18,000 B.t.u., the equivalent B.t.u. input for the fan requirements is (0.65 × 0.746 × 18,000) ÷ (0.85) = 10,250 B.t.u. per 1000 lb. of steam. If 130 B.t.u. per lb. are added to the water by the economizer, a total of 130,000 B.t.u. per

1000 lb. is the gross heat addition. The net heat addition is 130,000 — 10,250 = 119,750 B.t.u. so that the fan requires 7.9 per cent of the gross heat saving. Should the gas flow be increased to G ÷ A = 12,000 lb., the fan power per 1000 lb. of steam would be (from Fig. 5) increased to 1.15 and under the same conditions would require 18,200 B.t.u. or 14 per cent of the gross heat saving by the economizer.

Figure 6 is a plot of the equation for per cent coal saving,

$$\text{Saving} = \left(\frac{t_2 - t_1}{H_1 + 32 - t_1}\right) \times 100 \qquad \text{IV}$$

where $t_2 - t_1$ is the temperature rise in the feedwater and H_1 is the total heat per pound of steam. This curve can be used in two ways, either to show the temperature rise required in the feedwater for a predetermined per cent saving, as shown by the arrowed lines, or by starting at both top and bottom, the per cent saving due to a given temperature rise under known boiler conditions.

Methods of using these curves are shown by the following economizer problem, using the data and results as plotted on Figs. 7 to 13. The assumed conditions are: a boiler operating at 120,000 lb. of steam per hour, with 1240 B.t.u. total heat in the steam (above 32 deg.). Water entering the economizer is at 200 deg. F. and the temperature of the flue gases entering the economizer 700 deg. F. The fan is motor driven and the plant makes a kilowatt-hour on 16,000 B.t.u. The operating hours are 4500 per year. Coal costs $3.50 per t. and contains 13,000 B.t.u. per lb. Economizer surface costs $3.75 per sq. ft. installed; the fan and motor costs are $50 per kw. of fan power with interest and other charges figured at 20 per cent per year. If the boiler operating efficiency without economizer is 72 per cent, then the required coal costs

$$\left[\frac{(1240 + 32 - 200)}{0.72 \times 13{,}000}\right] \times \left[\frac{120{,}000 \times 4500 \times 3.50}{2000}\right]$$

or $108,300 per yr. of 4500-hr. operation.

In Fig. 7 the gross heat saving for various temperature increase in feedwater, from 70 to 150 deg. F. is plotted, by using Fig. 6. This saving, as shown by the curve, is a straight line which varies from 6½ per cent for a 70 to 14 per cent for a 150-deg. F. temperature rise. The lower set of curves on this sheet shows; the amount of economizer heating surface required to obtain this saving; values of gas flow, G ÷ A, varying from 5000 to 12,000 lb. These curves are obtained directly from Fig. 3 for 200 and 700 deg. F. inlet water and gas temperatures respectively, and a ratio of gas to water of 1.5. The amount of heating surface is shown per 1000 lb. of steam and must be multiplied by 120 to obtain the actual surface.

To obtain the actual savings, fan power must be deducted and to obtain the fan power, the exit gas temperatures must be calculated. From Fig. 4 can be found the exit gas temperatures as plotted on the lower part of Fig. 8 and from Fig. 5, values of fan power per 1000 lb. of steam for varying feedwater temperature rise and for gas flows of 8000, 9000, 10,000, and 12,000 lb. per hr. per sq. ft. free area through the economizer, as plotted on the upper portion of Fig. 8. Using a fan motor efficiency of 85 per cent (including line and all other losses), the B.t.u. equivalent of the fan power is calculated by multiplying the fan horsepower by the factor $\frac{0.746 \times 16{,}000}{0.85}$ = 14,050. The actual total kilowatts used by the fan for this boiler when producing 120,000 lb. of steam per hour is obtained by multiplying the figures shown in Fig. 8 by the factor $\frac{0.746 \times 120}{0.85}$ = 105.2 kw. input for each fan horsepower per 1000 lb. of steam.

Data plotted, Figs. 7 and 8, are sufficient to calculate and plot the performance of the different economizers and to determine, the maximum net saving in money, the net return on the investment, the best temperature

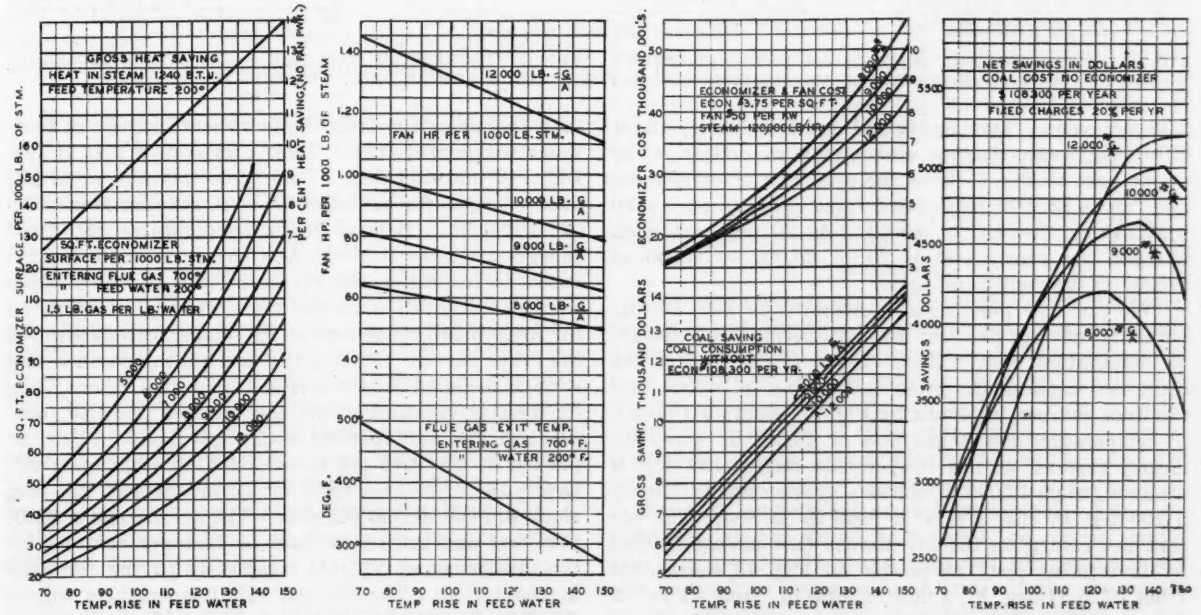


FIG. 7. GROSS HEAT SAVINGS FIG. 8. FAN POWER PER 1000 LB. OF STEAM FIG. 9. GROSS SAVINGS IN DOLLARS
FIG. 10. NET SAVINGS IN DOLLARS

rise and the best gas flow to be used. These are plotted in Figs. 9 to 13, showing the complete analysis of the problem.

Figure 12 shows the actual coal saving for various feedwater temperature rises and because of the increase in fan power for an increase in gas velocity, for several values of G ÷ A as well. The method of plotting this curve is: From the total coal saving, shown in Fig. 7, the equivalent fan power heat input is calculated by taking the values from Fig. 8 and multiplying by 14,050 B.t.u. This B.t.u. equivalent divided by (1240 + 32 — 200) × 1000 = 1,072,000 is the per cent coal used by the fan per 1000 lb. of steam. Thus for G ÷ A = 9000 and a 100-deg. F. temperature rise the coal equivalent is $\frac{0.74 \times 14{,}050}{1{,}072{,}000} = 0.0097$ or 0.97 per cent. The gross heat saving for a 100-deg. F. temperature rise from Fig. 7 is 9.35 per cent so the net saving is 9.35 — 0.97 =

This does not tell the whole story, however, for if the investment is too large it is poor finance to get the last dollar of return. Figures 12 and 13 were made to show the dollar saving and the per cent return on the investment for increment rise in feedwater temperature. Figure 12 shows the increment increase in economizer cost for 10 deg. rise in feedwater temperature. This is not a fixed sum but increases as the temperature rise increases being, for G ÷ A = 10,000 lb., about $2500 for the additional surface required to increase the temperature from 70 to 80 deg., and $6500 to increase it from 140 to 150 deg. The heat saving (including fan power required) is practically constant for any temperature, being slightly greater than the theoretical saving from a 10 deg. rise, as the decrease in fan power with increasing heat absorption affects these values. Deducting the fixed charges accruing from the additional cost of the economizer, from the coal saving shown, we get the series of curves on the lower part, Fig. 13, which

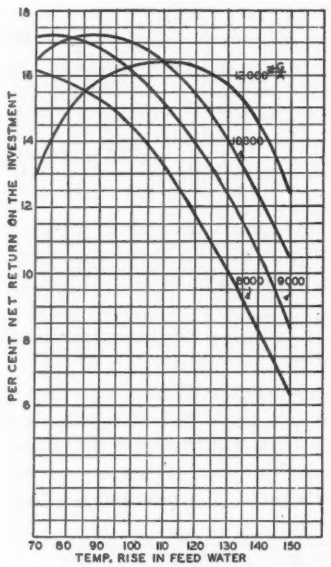


FIG. 11. PER CENT NET RETURN ON THE INVESTMENT

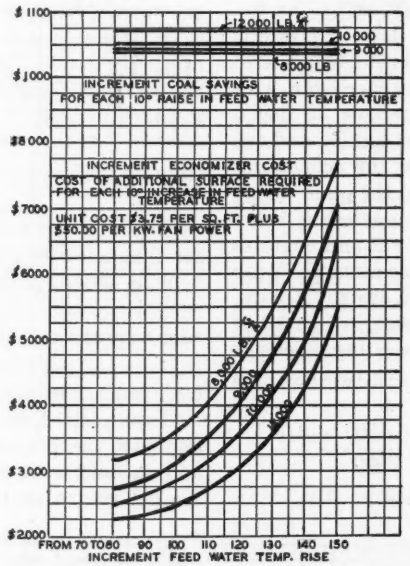

INCREMENT COAL SAVINGS FOR EACH 10° RAISE IN FEED WATER TEMPERATURE
INCREMENT ECONOMIZER COST
COST OF ADDITIONAL SURFACE REQUIRED FOR EACH 10° INCREASE IN FEEDWATER TEMPERATURE
UNIT COST $3.75 PER SQ. FT. PLUS $50.00 PER KW. FAN POWER
INCREMENT FEED WATER TEMP. RISE
FROM 70 TO 80 90 100 110 120 130 140 150

FIG. 12. INCREMENT COST FOR EACH 10-DEG. TEMPERATURE RISE

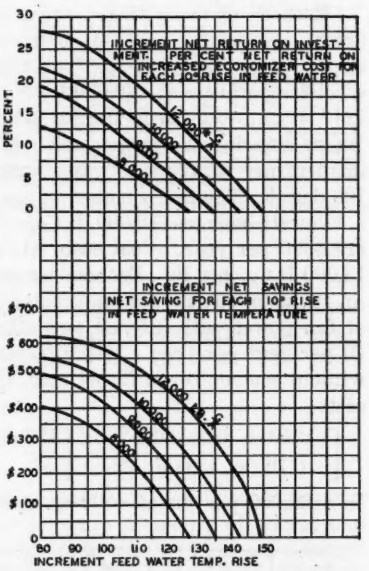

INCREMENT NET RETURN ON INVESTMENT: PER CENT NET RETURN ON INCREASED ECONOMIZER COST FOR EACH 10° RISE IN FEED WATER
PERCENT
INCREMENT NET SAVINGS
NET SAVING FOR EACH 10° RISE IN FEED WATER TEMPERATURE
INCREMENT FEED WATER TEMP. RISE
80 90 100 110 120 130 140 150

FIG. 13. INCREMENT NET SAVINGS FOR EACH 10-DEG. TEMPERATURE RISE

8.38 per cent. This multiplied by $108,300 is about $9100 per year, the net coal saving in dollars. The upper part of Fig. 9 shows the total cost of economizer and fan as $25,000 (calculated from (47.5 sq. ft. × 120 × $3.75) + (76 kw. × $50)). At 20 per cent fixed charges, the yearly cost is 20 × 25,000 = $5000 as shown on the right-hand scale.

We can now plot the curves shown by Fig. 10, the net dollar savings per year after deducting fixed charges on installation cost. These curves are of course the difference between the gross coal saving in dollars and the fixed charges, as shown by Fig. 9. Above a 100-deg. F. temperature rise a gas flow of 10,000 lb. saves the largest amount, until a temperature rise of 123 deg. is attained, when 12,000 lb. shows a greater saving. Below a 100-deg. F. rise, a flow of 9000 lb. is best. The per cent net return on the investment (net saving divided by investment cost) as plotted in Fig. 11 shows that from 70 to 81 deg. F., a flow of 9000 lb., from 81 to 109 deg. F. a flow of 10,000 lb., and from 109 to 150 deg. a flow of 12,000 lb. gives the largest returns in per cent. show the net saving from the increment increase in feedwater temperature rise. These curves show that at 128, 137, 142 and 149 deg. F. the gross savings equal the fixed charges, for values of G ÷ A ranging from 8000 to 12,000 lb. Beyond these temperatures the fixed charges are more than the heat saving as could be surmised by inspecting the curves in Fig. 10. The upper curves in Fig. 13 show the net differential returns on the investment, being zero at the temperatures shown on the lower curves. Thus if the last heating surface that is to be installed should earn a 10 per cent return, then the best installation is one that gives a 130 deg. temperature rise and operates with a gas flow of 12,000 lb. per sq. ft. free area per hour. Such an economizer will have (57 × 120) = 6850 sq. ft. of surface, will save about $11,500 in coal per year. The net savings is $5000 per year and returns a total of 15.4 per cent net on the investment of $32,000, completely paying for itself in about 6 yr. The flue gas exit temperatures will be 330 deg. F. and the fan power chargeable to the economizer will be 125 kw. This 125 kw. is in addition to

the power required to furnish draft for the boiler and combustion.

Conclusion

To show that the trouble involved in an analysis of this kind is worth while, let us check through on an economizer installation of the usual type found in practice. It is usual to install from 75 as high as 100 per cent of the boiler heating surface in the economizer. Let us take the lower value of 75 per cent, using a G ÷ A of 8000 lb., another common figure. This boiler when steaming at 120,000 lb. per hr. with 700 deg. exit flue gases, is evaporating about 10 lb. of water per square foot of boiler heating surface, therefore it is a 12,000 sq. ft. boiler. The economizer is 75 per cent of 12,000 is 9000 sq. ft., equal to 75 sq. ft. per 1000 lb. of steam. From Fig. 7 we see that 75 sq. ft. at G ÷ A = 8000 will give a temperature rise of 122 deg., a heat saving of 11.4 per cent, a flue gas exit temperature of 350 deg. and use 0.545 hp. per 1000 lb. of steam for the fan power, requiring a total of 57.5 kw. fan input. Figure 9 shows that the gross savings are slightly over $11,500 and that the installation cost is $35,300. Net saving, from Figs. 10 and 11, is only $4200 per year, giving a net return on the investment of 11.5 per cent. Compared to the first analysis, the correct economizer for these conditions shows an increase in the net savings of $800 per year on an investment $3300 lower.

Should the use of a preheater after the economizer be required, the calculations will probably show that a higher exit flue gas temperature from the economizer is necessary so that a lower feedwater temperature rise and therefore less economizer surface should be used. This means that for G ÷ A equal to about 9000 lb. will be best if the temperature rise is less than 100 deg. F., or G ÷ A equal to about 10,000 for a temperature rise of 100 to 122 deg. F. All of these calculations are simplified by constructing curve sheets No. 1 to No. 6, and following through the methods and plots outlined in this article. In all problems of this type, plotting of data and results rather than tabulation alone is advisable, not only to obviate mathematical errors but also to prevent hasty and incorrect conclusions.

With the exception of water and air driven prime movers which date back to the period before the Christian Era, the history of prime movers is very recent, beginning, perhaps, with the first really successful steam engine about 1765. The hot air engine of Stirling appeared in 1816 and that of Ericsson about 1833, preceding the internal combustion engine of Lenoir in 1860 by many years. The Lenoir engine was short lived, however, being followed by the Otto and Langen free piston engine in 1867, the Braylor or Joule engine of 1870, the silent Otto of 1876, and finally the Diesel engine in 1897. The steam turbine as a commercial possibility begins about 1887 with the work of Parsons and DeLaval. In between these various steps were many developments that had an important bearing on the future. Many times developments took place almost simultaneously, so that it is often difficult or impossible to give proper credit to those deserving it.

Usually, it is best to adjust the receiver pressure in cross compound engines so that equal work is done in the two cylinders.

Carbon Packing Rings for Steam Turbines

In turbines employing carbon blocks for sealing the turbine shaft, it is important that they be properly fitted. These carbon blocks should have a low coefficient of friction and must not disintegrate under the action of superheated steam.

In service they should develop a highly polished surface necessary for an effective seal with low frictional losses and minimum wear on the shaft. After the turbine has passed its initial tests, it is well to open the glands up and examine the rings. If not found smooth and polished, the blocks should be smoothed down and readjusted.

Provided the spring pressure is not excessive, properly adjusted carbon blocks cause but slight wear on the shaft. They must, however, be perfectly clean and free from grit and the shaft must be free from rust. When these packings are removed during overhauling, all sections of the packing and shaft should be thoroughly examined for grooving, scoring and wear. If it is necessary to refit or renew any section, they should be dressed until they fit the shaft snugly and the ends of all the blocks bed snugly together. Springs should be examined and tested and if found to be weak or corroded, should be renewed.

Trouble sometimes results from causes hard to trace. For instance, in one case trouble was experienced through the springs losing their elasticity, cracking, breaking and entering the turbine. Various springs were tried with no better results; cracks in each case were found where they made contact with the carbon although the other parts seemed sound. The springs were given a micrographic examination and the fractures appeared to be similar to those caused by electrolytic action.

It appeared that the trouble might be due to circulating currents in the shaft. It was decided to break electrical contact between the springs and the carbon, by coating the grooves of the carbon packing with an insulating wash and coating the springs with an insulating varnish. After this there was no further trouble. It was afterwards found that circulating currents present in the shaft were caused by unequal air gaps at the alternator.

It is important that shaft packing be kept in first-rate condition to avoid possible steam or vacuum losses.

Too much care cannot be used in the handling, cleaning, and selection of gage glasses; the higher the pressure the more care is necessary, as with high pressure the life of a gage glass is short enough at best without deliberately shortening its life. Wire or metal should never be used to clean gage glasses, as it is almost impossible to keep from scratching the surface, and the smallest scratch causes breakage as soon as the glass is heated and temperature strains introduced. For high pressures, glasses should be ordered the correct length and with two fused ends as a cut end will not normally give as good service as a fused end. If the glass must be cut, however, the cut end should be placed at the bottom where it is free from the erosive action of the steam and condensate droplets.

Testing Pulverized Coal Fineness *with Sieves*

COMPARISON OF SIZES INDICATES THAT A.S.T.M. (U. S. STANDARD) AND TYLER SERIES GIVE RESULTS SUBSTANTIALLY IN AGREEMENT

IN PRACTICE, the sizes of pulverized coal particles are referred to as those that will pass through or be retained on a wire sieve. Openings in the sieve, and consequently the dimension of the resulting product that will pass through, are determined by the size of the wire and the number of wires per inch, commonly known as the mesh. Thus 70 per cent through 200 mesh means that 70 per cent of the coal is pulverized fine enough to pass through a standard screen with openings of 0.0029 in. (0.074 mm.) between the wires, while a 100/200 product means that the particles will pass a 100 screen with openings of 0.0059 in. (0.147 mm.) and will be retained on a 200 screen.

In this country and for this purpose, the Tyler and A.S.T.M. sieve series are standard and for all practical purposes identical. The German Reich Coal Council and the British I.M.M. standards will be discussed later. The A.S.T.M. is the same as the U.S. Standard, developed by the Bureau of Standards and used by the Bureau of Mines, with the exception of the method of designation. The U. S. Standard is designated by sieve numbers which approximate the mesh; the A.S.T.M. is designated microns (0.001 mm.); the screen micron number corresponding to the width opening in microns; that is, U. S. No. 200 is the A.S.T.M. 74 micron sieve. The Tyler series is designated by mesh.

In fact, mesh is the common or popular way of referring to all series regardless of the fact that its use is discouraged. In the old days when each manufacturer made the wire cloth according to his own specifications, mesh had little meaning but now that wire sizes and openings have been standardized the term mesh hangs on as a matter of habit like boiler horsepower.

The complete Tyler and A.S.T.M. series are virtually the same, each sieve in the series bears a geometric relation to the others. This relation is $\sqrt[4]{2} = 1.189$, meaning that each screen has an opening 1.189 times the opening of the next lower one in the series. By selecting the proper sieves, the product retained on each pan will bear a definite relation to each of the others. Using every fourth sieve, the product will be twice the diameter of the next lower; using every sixth pan, the product will be one-third the diameter of the next lower and so on.

In the A.S.T.M. series, the starting point is 1 mm. while in the Tyler the starting point is the 200 mesh screen with an opening of 0.029 in. (0.074 mm.). This point was determined as a standard by the Bureau of Standards many years ago and as such used by the Tyler Co. when they brought out their standard series in 1910. Difference in wire size makes the two series, Tyler and A.S.T.M., differ in some respects.

It is not uncommon to hear criticism of published tests because the screen series is not given. It is, however, readily apparent to one familiar with them because

TABLE I. COMPARISON OF SEVERAL WIDELY USED SIEVE SERIES

Number or Mesh per in.	A.S.T.M. (U.S.Std) Opening in.	A.S.T.M. (U.S.Std) Dia. wire in.	A.S.T.M. (U.S.Std) Actual Mesh	Tyler Opening in.	Tyler Dia. wire in.	German Reich U.S. Equiv.	German Reich Mesh per sq.cm.	German Reich Dia. wire in.	German Reich Opening in.	I. M. M. Opening in.	I. M. M. Dia. wire in.	I. M. M. Ratio to one below	H. & M. Opening in.	H. & M. Dia. wire in.	H. & M. Ratio to one below	Number or Mesh per in.
2½	0.315	0.073	2.58	0.312	0.066	2½										2½
3	0.265	0.065	3.03	0.263	0.070	3										3
3½	0.223	0.057	3.57	0.221	0.065	3½										3½
4	0.187	0.050	4.22	0.185	0.065	4							0.201	0.049	1.535	4
5	0.157	0.044	4.98	0.156	0.044	5				0.1	0.1	1.61				5
6	0.132	0.040	5.81	0.131	0.036	6							0.131	0.035	1.370	6
7	0.111	0.0360	6.80	0.110	0.0328	7										7
8	0.0937	0.0331	7.89	0.093	0.032	8				0.062	0.063	1.24	0.0955	0.0295	1.305	8
9				0.078	0.033	10										9
10	0.0787	0.0299	9.21	0.065	0.035	12				0.05	0.05	1.20	0.073	0.027	1.246	10
12	0.0661	0.0272	10.72	0.055	0.028	14				0.0416	0.0417	1.33	0.0583	0.025	1.210	12
14	0.0555	0.0240	12.58	0.046	0.025	16							0.0485	0.023	1.153	14
16	0.0469	0.0213	14.66	0.0390	0.0235	18				0.0312	0.0313	1.25	0.0480	0.0205	1.146	16
18	0.0394	0.0189	17.15										0.0368	0.01875	1.095	18
20	0.0331	0.0165	20.16	0.0328	0.0172	20				0.025	0.025	1.25	0.0335	0.0165	1.198	20
24													0.02795	0.01575	1.315	24
25	0.0280	0.0146	23.47	0.0276	0.0141	25				0.02	0.02	1.205				25
28				0.0232	0.0125	30										28
30	0.0232	0.0130	27.62							0.0166	0.0167	1.17	0.02108	0.01225	1.228	30
32				0.0195	0.0118	35										32
35	0.0197	0.0114	32.15	0.0184	0.0122	40				0.0142	0.0143	1.135	0.01732	0.01125	1.173	35
40	0.0165	0.0098	38.02							0.0125	0.0125	1.25	0.01475	0.01025	1.134	40
42				0.0138	0.0100	45										42
45	0.0138	0.0087	44.44													45
48				0.0116	0.0092	50										48
50	0.0117	0.0074	52.36							0.01	0.01	1.20	0.011	0.009	1.218	50
60	0.0098	0.0064	61.93	0.0097	0.0070	60				0.0085	0.0083	1.17	0.009	0.0057	1.150	60
65				0.0082	0.0072	70	900	0.0051	0.0079							65
70	0.0083	0.0055	72.46							0.0071	0.0071	1.145	0.0078	0.0065	1.150	70
80	0.0070	0.0047	85.47	0.0069	0.0056	80				0.0062	0.0063	1.24	0.00675	0.00575	1.121	80
90										0.0055	0.0055	1.10	0.006	0.005	1.091	90
100	0.0059	0.0040	101.01	0.0058	0.0042	100	1600	0.0039	0.0059	0.005	0.005	1.51	0.0055	0.0045	1.119	100
110													0.005	0.004	1.083	110
115				0.0049	0.0036	120	2500	0.0032	0.0047							115
120	0.0049	0.0034	120.48							0.0042	0.0041	1.273	0.0046	0.0036	1.134	120
130													0.0041	0.0036	1.040	130
140	0.0041	0.0029	142.86										0.0039	0.0032	1.100	140
150				0.0041	0.0026	140				0.0035	0.0033	1.32	0.0035	0.003	1.035	150
160													0.00345	0.0026	1.061	160
170	0.0035	0.0025	166.67	0.0035	0.0024	170	4900	0.0022	0.0035				0.0033	0.0026	1.052	170
180													0.0031	0.0024	1.000	180
190													0.0031	0.0022	1.111	190
200	0.0029	0.0021	200.00	0.0029	0.0021	200	6400	0.0020	0.0030	0.0025	0.0025		0.0028	0.0022		200
230	0.0024	0.0018	238.10				10000	0.0016	0.0024							230
250				0.0024	0.0016	230										250
270	0.0021	0.0016	270.36	0.0021	0.0016	270										270
325	0.0017	0.0014	323.00	0.0017	0.0014	325										325

the appearance of 24, 28, 32, 42, 48, 65, 80, 115 or 150 identifies it immediately as the Tyler series because those numbers do not appear in the A.S.T.M. series, while 18, 25, 30, 40, 50, 70, 120 or 140 identifies it as the A.S.T.M. or U. S. Standard.

A comparison of Table I showing the Tyler and A.S.T.M. sizes will show that in the range in which we are interested, that is, from 48 or 50 mesh down, there is no need for confusion, they agree well within the tolerance limit set by the A.S.T.M. U.S. 140 is equivalent to Tyler 150; U. S. 120, Tyler 115; U. S. 70, Tyler 65; U. S. 50, Tyler 48; U. S. 45, Tyler 42 and U. S. 35 Tyler 32. Those numbers, such as, 200 and 100 that are common to both series are in virtual agreement except in the case of 35 where Tyler 35 is equal to U. S. 40 and U. S. 35 is equal to Tyler 32. The equivalent number of each series is given in Table I.

A survey of American manufacturers interested in pulverized coal equipment indicates that they favor the use of the Tyler series about 2 to 1 while coal analyses from the N.E.L.A. proceedings indicate that operators favor the A.S.T.M. series in about the same ratio. In some cases, manufacturers gave the sieve sizes most used and although they stated that they used the Tyler Series, the sieve numbers indicated the use of the U. S. Standard, so that too much reliance cannot be placed on the replies.

Tabulation of data from N.E.L.A. reports shows sizes 20, 28, 30, 40, 48, 50, 60, 80, 100, 150, 170 and 200 used in power plants. Of these curiously enough, 40, 60, 100 and 200 are the most common, indicating that they are probably picked out by trying to space the screen numbers without a great deal of thought as to the relation of the various sizes or recommendations of the A.S.T.M.

In the interest of consistence of test results and to have data taken by Tyler or A.S.T.M. sieves directly comparable, U. S. Nos. 30 (Tyler 28), 50 (Tyler 48), 100 and 200 should be used. In this combination, each sieve opening is twice that of the next smaller sieve and Tyler and U. S. readings are the same. If intermediate values are wanted, U. S. Nos. 140 (Tyler 150) and 70 (Tyler 65) are the logical ones to use. This gives a progressive increase in diameter of 1.414 for each sieve from 0.0029 in. at No. 200 to 0.0117 in. at No. 50 as follows: 0.0029; 0.0041; 0.0059; 0.0083 and 0.0117 in.

The size of the product is in a geometrical ratio in contrast with the arbitrary size grouping obtained when using 40, 60, 100 and 200 sieves. For particular installations intermediate sizes can be used as necessary. For instance, a test on one type of mill shows 95 per cent through 100 mesh and about 70 per cent through 150 mesh. In this case, a 115 mesh screen might be desirable to show where the curve breaks sharply.

In general, however, with the four sieves mentioned above, i.e., 30, 50, 100 and 200, the data from all tests will be comparable, any additional steps merely adding to the completeness of the data. Inasmuch as many engineers feel that the coal through the 48 or 50 sieve is a measure of efficient combustion and it seems pretty well agreed that practically all the coal should go through this sieve, there is little need for sieves finer than this with the possible exception of a 28 or 30 sieve to indicate excessively large particles.

In Germany, the Reich Coal Council adopts the series shown in Table II. Wire diameters are somewhat different from American practice and the screen number is the number of wires per centimeter. The mesh as they use it is the number of holes per square centimeter. According to this definition, our 100 sieve would become a 10,000 mesh per sq. in. or if metric units were used about 1600 mesh per sq. in. about the same as the German No. 40.

In England the Institute of Mining and Metallurgy developed a series known as the IMM about 1907. This series has an arbitrary ratio between sieves, averaging about 1.232 and there are 14 screens between 20 and 200 mesh as compared to 15 for the American screens. The attempt was made to have wire diameter equal to the width of opening, thus giving a screen opening of about 25 per cent of the total area. Another series

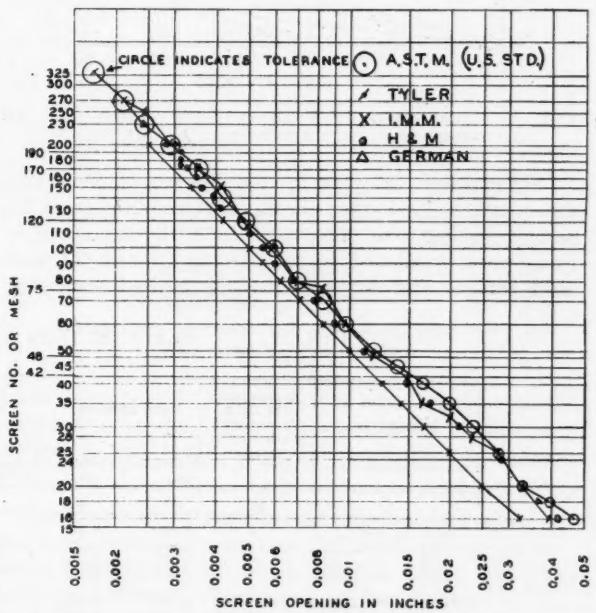


FIG. 1. GRAPHICAL COMPARISON OF SIEVE SERIES. THE CIRCLE ON THE A. S. T. M. CURVE INDICATES THE TOLERANCE

that has been used in this country for over 30 yr. and which is probably the first permanent complete standard in this country is the Howard & Morse, data for which is also given in Table II.

Rittinger, about 1867, proposed the series with the ratio of $\sqrt{2}$ or 1.414 with the starting point of 1 mm. This allows only 7 screens in the four sizes between 20 and 200 mesh and Richards proposed a series sometimes called the double Rittinger with the ratio $\sqrt[4]{2} = 1.189$, with the same starting point. This gives 15 sieves between 20 and 200 mesh.

Other proposed series include the Hoover or Statler in which the ratio was the $\sqrt[3]{2} = 1.26$ and includes both the inch and millimeter but has no other advantage. In addition, it has only 11 fine screens. The DeKalb series starts with 0.003 as the smallest opening, the succeeding openings being formed by adding 0.001 N to the opening of the preceding screen, N being the number of screens in the series. In the Belharz the ratio between screens is the Nth root of 10 or $\sqrt[N]{10}$. In a

series of N + 1 sieves the diameter of the smallest hole will be 0.1 that of the largest. Any scale can be used, and with five screens the ratio would be $\sqrt[4]{10} = 1.78$ and starting with 1 the openings would be 1, 1.78, 3.16, 5.63 and 10. A 9 sieve screen would have the ratio $\sqrt[8]{10} = 1.333$ giving openings of 1, 1.333, 1.78, 2.38, 3.15, 4.21, 5.62, 7.5 and 10. Any series can be extended in either direction by changing the decimal point.

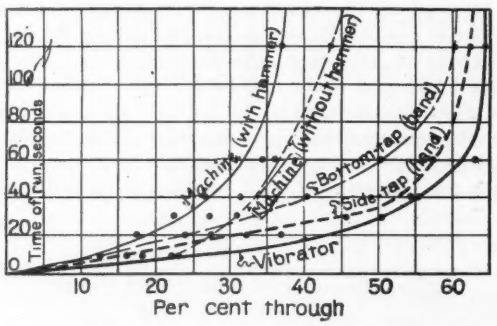


FIG. 2. WIDE VARIATION IN SCREEN TESTS CAN BE OBTAINED BY DIFFERENT SHAKING METHODS

Standardization work by the Bureau of Standards dates back to 1904 when the No. 100 and 200 sieves for cement testing were adopted. In 1912, the specifications were broadened to include the 20 and 30 mesh sand screens and the specifications revised somewhat. Other revisions in 1914, 1916 and 1919 lead up to the present specifications. In 1924, the tolerances were increased in some cases and were proposed as tentative by the A.S.T.M. and adapted as standard by the route in 1926 (Standard Specifications for sieves for testing purposes Serial Designation E 11-26). For laboratory use the 8-in. diameter sieve is practically standard although for special uses sieves are made from 3 to about 18 in. in diameter.

Too much emphasis cannot be placed upon the effect of sieve handling upon the screening results. As an example of the results that can be obtained by different methods, Fig. 3 is reproduced from a recent Bureau of Mines report Serial 2933, "Effect of Sieve Motion on Screening Efficiency." This particular test made on crushed quartz is the worst of the series and has been chosen more as a horrible example than as average condition.

The side tap method of sieving mentioned above; in fact, the entire procedure of preparing the sample and making the test is described in "Method of Test for Fineness of Powdered Coal" A.S.T.M. designation D 197 as in part is as follows:

"A 50-g. sample of the air-dried coal shall be placed on the No. 200 sieve, to which a pan and cover shall be attached. The sieve shall be held in one hand in a slightly inclined position, so that the sample will be well distributed over the sieve, while at the same time the operator shall gently strike the side about 150 times per minute against the palm of the other hand on the up stroke. Every 25 strokes the sieve shall be turned about one-sixth of a revolution in the same direction. The sieve shall be held over a sheet of glazed white paper during the sieving operation, so as to detect any loss that might result from accidental spilling of a portion of the sample, in which case another sample shall be taken."

For rapid routine tests, machines which shake the pans mechanically are usually used although the hand method is standard. The following method is used by one large manufacturer:

"We have found the standard recommendations of the A.S.T.M. satisfactory for our purpose. Their recommendations, as you know, are the use of the U. S. Standard Sieve Series, using the 16, 30, 50, 100 and 200 mesh screens. We also follow the hand method of screening as proposed by the A.S.T.M. for the final fin-

TABLE II. DATA ON THE A.S.T.M. SERIES

Designation	Corresponding U. S. Standard Sieve Series Number	Sieve Opening		Wire Diameter		Tolerance in Average Opening, per cent	Tolerance on Wire Diameter, per cent		Tolerance in Maximum Opening, per cent
		mm.	in.	mm.	in.		Under	Over	
1	2	3	4	5	6	7	8	9	10
4760 micron.....	4	4.76	0.187	1.27	0.050	±3	15	30	10
4000 "	5	4.00	0.157	1.12	0.044	±3	15	30	10
3360 "	6	3.36	0.132	1.02	0.040	±3	15	30	10
2830 "	7	2.83	0.111	0.92	0.036	±3	15	30	10
2380 "	8	2.38	0.0937	0.84	0.0331	±3	15	30	10
2000 "	10	2.00	0.0787	0.76	0.0299	±3	15	30	10
1680 "	12	1.68	0.0661	0.69	0.0272	±3	15	30	10
1410 "	14	1.41	0.0555	0.61	0.0240	±3	15	30	10
1190 "	16	1.19	0.0469	0.54	0.0213	±3	15	30	10
1000 "	18	1.00	0.0394	0.48	0.0189	±3	15	30	10
840 "	20	0.84	0.0331	0.42	0.0165	±5	15	30	25
710 "	25	0.71	0.0280	0.37	0.0146	±5	15	30	25
590 "	30	0.59	0.0232	0.33	0.0130	±5	15	30	25
500 "	35	0.50	0.0197	0.29	0.0114	±5	15	30	25
420 "	40	0.42	0.0165	0.25	0.0098	±5	15	30	25
350 "	45	0.35	0.0138	0.22	0.0087	±5	15	30	25
297 "	50	0.297	0.0117	0.188	0.0074	±6	15	35	40
250 "	60	0.250	0.0098	0.162	0.0064	±6	15	35	40
210 "	70	0.210	0.0083	0.140	0.0055	±6	15	35	40
177 "	80	0.177	0.0070	0.119	0.0047	±6	15	35	40
149 "	100	0.149	0.0059	0.102	0.0040	±6	15	35	40
125 "	120	0.125	0.0049	0.086	0.0034	±6	15	35	40
105 "	140	0.105	0.0041	0.074	0.0029	±8	15	35	60
88 "	170	0.088	0.0035	0.063	0.0025	±8	15	35	60
74 "	200	0.074	0.0029	0.053	0.0021	±8	15	35	60
62 "	230	0.062	0.0024	0.046	0.0018	±8	15	35	90
53 "	270	0.053	0.0021	0.041	0.0016	±8	15	35	90
44 "	325	0.044	0.0017	0.036	0.0014	±8	15	35	90

ishing of the 200 mesh results. We do, however, make use of Ro-Tap machines for doing the preliminary screening, as it saves considerable time and can be doing this preliminary shaking while the operator is doing the final shaking of the 200 mesh screen by hand. We find the machine method entirely satisfactory for the coarser screens, so that our standard procedure is to put a sample in the machine, run it for 10 minutes, remove it, dumping the various sizes into separate pans, immediately put a new sample into the machine and start it going again; the operator then weighs up the material retained on the coarser sieves and shakes the material left on the 200 mesh by hand, with weighings every minute until check weighings have been obtained. This method, we believe, gives us the accuracy of hand shaking with check weighings on the 200 mesh combination but with practically the same speed that machine operation can give in doing a large quantity of routine analysis."

Effect of Air on Condenser Tube Deterioration

SUMMARY OF STUDIES MADE IN STATIONS OF BROOKLYN EDISON CO. AND OF PROBLEMS AWAITING INVESTIGATION

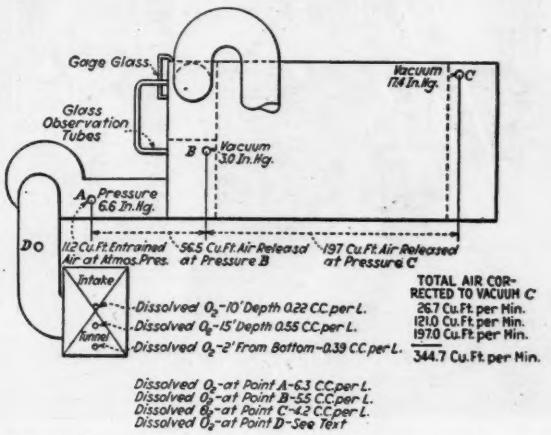
DURING THE PAST YEAR, studies have been made to determine the quantities of air and the degree of turbulence within condenser water boxes and tubes and correlating this data with tube deterioration. The work has been carried out principally in the Hudson Ave. and Gold Street stations of the Brooklyn Edison Co.

In general, the field work consisted of obtaining samples at points illustrated in the diagram at various places in the circulating water cycle. Complete data are tubulated with the sketch and show a decided increase in the volume of air from the inlet tunnel to the condenser discharge due to the release of air with drop in pressure.

In carrying out the experiments in the field, the infiltration of air through circulating water pump glands emphasized the importance of the water seal. Another source of entrained air which is under investigation is the possibility of a vortex in the suction leg. In order to determine the effect of such a vortex samples were taken on the suction leg during operation of the dump and then periodically after the pump was shut down so that any air in the center of the suction leg would have an opportunity to diffuse. Samples obtained at point D, with the pump operating, indicated 0.10 c.c. of dissolved oxygen per liter, 20 min. after the pump was shut down the dissolved oxygen at the same point was 1.55 c.c. per liter and after 30 min. this increased to 1.88 c.c. per liter. The increase in the amount of air near the side of the pipe after the shutdown of the pump would indicate that air is being sucked through the center of the column of water and that in passing through the impeller this air is more thoroughly mixed with the water. This, rather than gland leakage, accounts for the higher air content after passing through the pump.

Samples of circulating water were placed in a bottle, subjected to various degrees of vacuum and the release of entrained air noted. A maximum of 344.7 cu. ft. per min. of entrained air corresponding to 2.57 per cent of the total flow was found to be entering the second pass.

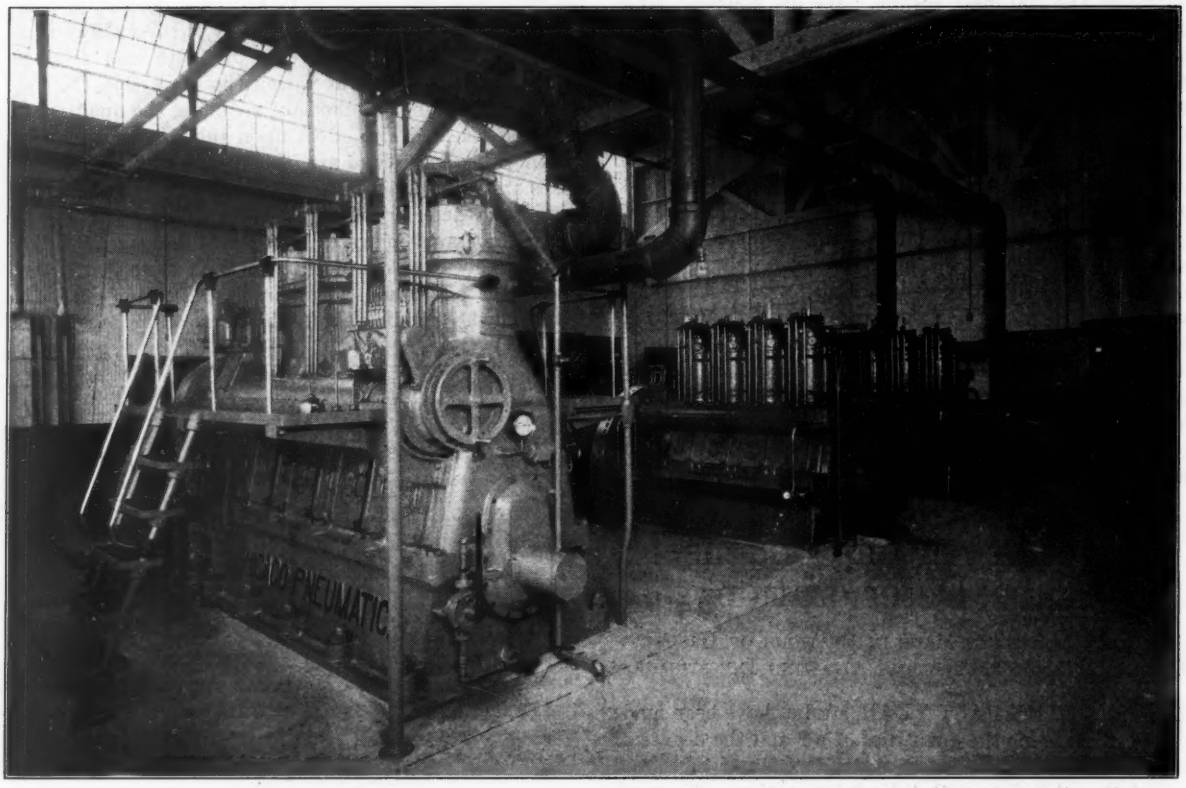
Outline of work to be covered by further study is as follows: Quantity of air entering with and released with circulating water at various points within the condenser and piping; methods of reducing the quantity of free and released air; effect upon tube deterioration by varying the quantity of air; turbulence within the water boxes and tubes; means to reduce this turbulence; effect upon tube deterioration by varying degrees of turbulence; the extent of water level fluctuation in the upper rows of tubes and the length of time these contain no water; the pH value of the circulating water should be determined. Studies are to be carried on in existing plants and printed forms for data have been prepared so that those in the position to assist in the studies can fill these in and send them in for correlation with other data.


Gage Glass
Glass Observation Tubes
Vacuum 1.14 In. Hg.
C
B
Vacuum 30 In. Hg.
A
Pressure 6.6 In. Hg.
D
1.12 Cu. Ft. Entrained Air at Atmos. Pres.
56.5 Cu. Ft. Air Released at Pressure B
1.97 Cu. Ft. Air Released at Pressure C
Intake
Tunnel
Dissolved O2-10' Depth 0.22 CC per L.
Dissolved O2-15' Depth 0.55 CC per L.
Dissolved O2-2' From Bottom-0.39 CC per L.
TOTAL AIR CORRECTED TO VACUUM C
26.7 Cu. Ft. per Min.
121.0 Cu. Ft. per Min.
197.0 Cu. Ft. per Min.
344.7 Cu. Ft. per Min.
Dissolved O2-at Point A-6.3 CC per L.
Dissolved O2-at Point B-5.5 CC per L.
Dissolved O2-at Point C-4.2 CC per L.
Dissolved O2-at Point D-See Text

DIAGRAMMATIC SKETCH OF INVESTIGATION OF AIR QUANTITIES IN CONDENSER

UNITED STATES CIVIL SERVICE COMMISSION announces open competitive examination for associate marine engineer, applications for which must be on file with the U. S. Civil Service Commission at Washington, D. C., not later than November 19, 1930. Entrance salaries range from $3200 to $3800 a year. This examination is to fill vacancies in the office of the Coast Guard, Treasury Department, Washington, D. C., and in the field. Competitors will not be required to report for examination at any place, but will be rated on their education, experience and fitness. Applicants must be graduates of a technical college of recognized standing, in engineering, or of a recognized school of naval architecture and marine engineering. In addition thereto, applicants must have had not less than 3 yr. of progressive professional experience along certain specified lines. Full information may be obtained from the United States Civil Service Commission, Washington, D. C., or from the Secretary of the United States Civil Service Board of Examiners at the post office or customhouse in any city.

APPLICATION of direct connected synchronous motors to compressor drives is a comparatively recent development. At first it was not altogether successful, because of improper flywheel effect, but this was soon corrected and this combination is now the most popular type of compressor drive.



Diesel Engines for Industrial Power in Heart of Chicago

DEPENDABLE POWER for 24 hr. each day is required by the Vesta Battery Corporation. All of its machinery is motor driven and hundreds of storage batteries manufactured at the plant are being charged on a fixed production schedule. Most of this charging is done during the night, thus permitting balancing the 24-hr. load.

Plant Independent of All Outside Power

Electricity for the lighting load is also furnished by the Diesel-driven generators which supply all of the power for the entire plant. No electricity is purchased and no connection with outside power sources have been established.

From the charts taken from an Esterline-Angus recording ammeter, illustrated in Fig. 1, it will be seen that the heavier load is carried during the winter months and that both summer and winter loads are quite uniform. The load record for Nov. 5-6, shown at B, is quite typical and that of the next day Nov. 6-7, shown at C, shows a fluctuating load such as is encountered from time to time.

Two engine units, each of 160 hp., and one of 300-hp. are installed. All are of the Chicago Pneumatic M.W.M. Benz Diesel type and are 4-cycle, solid injection engines. The 160-hp. units, type R.H.—40, have four 10¾ by 13¾-in. cylinders and are direct connected to 100-kw. generators, while the 300-hp. unit, type R.H.—75, which has six 14 by 21-in. cylinders, is similarly connected to a 200-kw. generator. All of the generators were built by the Crocker-Wheeler Co. and are of the direct current type, operating at 250 v. The annual station output is estimated at 1,000,000 kw-hr. The loads on the plant vary from 50 to 300 kw-hr.

Construction Features of Engines

All of the engines have precombustion chambers as illustrated in Fig. 2, which is a cross-sectional view of the 300-hp. unit. The piston of this larger unit is fitted as shown with a ground-in conical insert in the head. Removable cylinder liners, cast of nickel-iron alloy, heat treated and ground to size; inlet and exhaust valves of silchrome steel in removable cages, the exhaust valves being water jacketed; main bearings lined with centrifugally poured babbit; means for removing the lower bearing shells without disturbing the position of the crankshaft and crankshaft of open-hearth vanadium-alloy steel forging which is heat-treated and then ground to size, are features of the engine construction.

Pressure lubrication is used and the lubricating oil after passing through the engine, drains to a sump just below the floor line and outside of the foundation, where it is cooled. The oil cooler consists of a coil of large seamless-copper tubing through which cooling water cir-

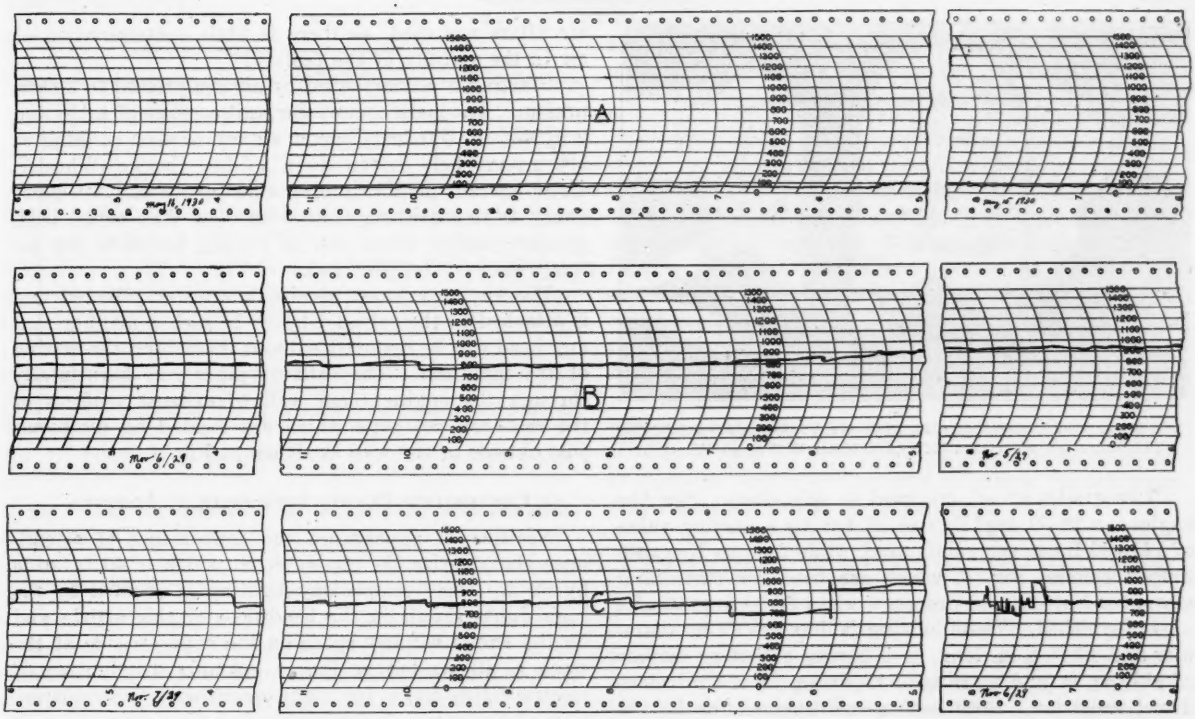


FIG. 1. LOAD CURVES SHOWING SUMMER AND WINTER LOADS AND UNIFORM AND FLUCTUATING PERFORMANCE

culates. This oil is clarified continuously by passing a portion of it through De Laval purifiers, the smaller engine units each having a vertical type, style 196 B and the larger unit, having a horizontal type, style 17 H machine. These lubricant reclaiming machines are cleaned every day of use.

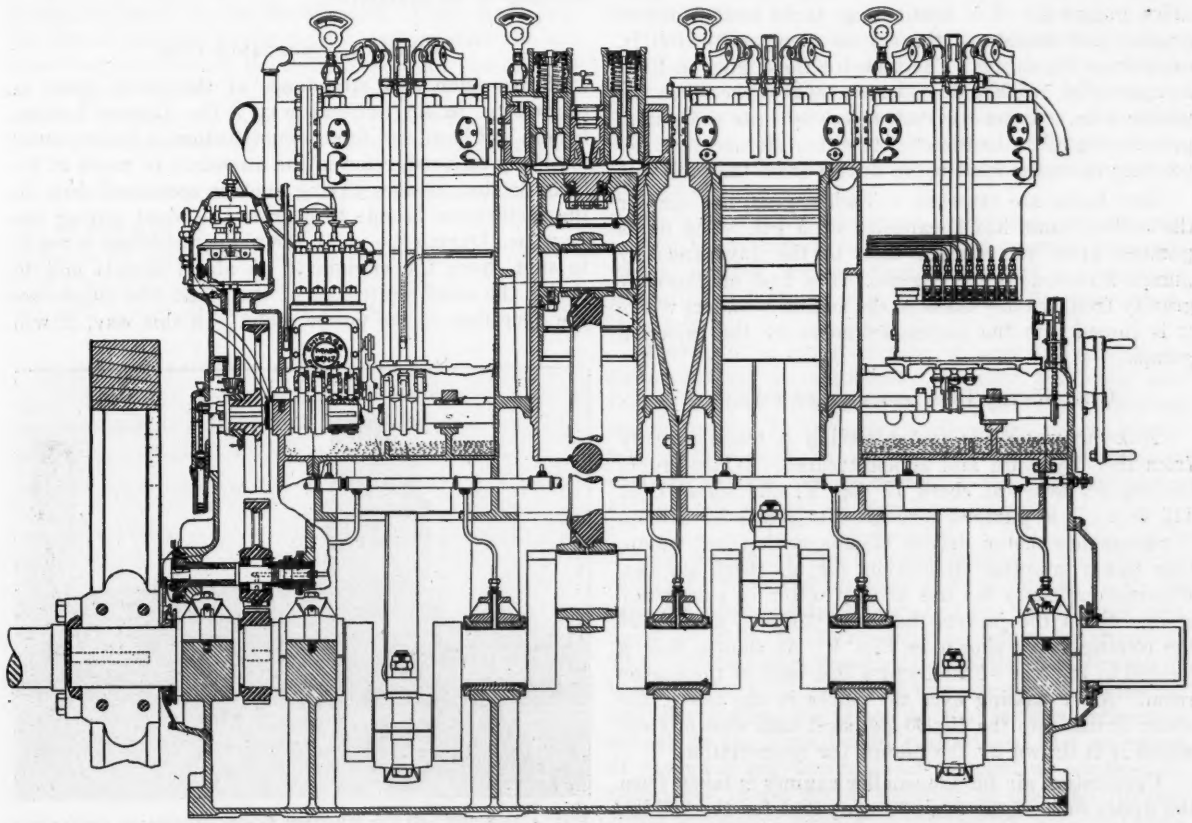


FIG. 2. CROSS-SECTION OF 300-HP. ENGINE SHOWING CONSTRUCTIONAL FEATURES

FIG. 3. KEWANEE BOILERS FOR HEATING AND PROCESS STEAM ARE AUTOMATICALLY FED WITH FUEL OIL

Two grades of oil are used in this plant. For the engines, a 28-30 deg. Baumé oil having a heating value of 141,700 B.t.u. per gal. is used, while for two Kewanee firebox boilers, Fig. 3, which are used for furnishing steam for heating and process work, a 28-30 deg. Baumé oil is furnished. These heating boilers are 72-in. diameter and 19 ft. 6 in. long, each having a heating surface of 1129 sq. ft. and a rating of 13,300 sq. ft. of equivalent direct radiation. Both boilers are designed for 100 lb. but operate at 25 lb. press. Heating effect is accomplished by size 5, type S.G.L. Ray oil burners having a capacity of 30 gal. per hr.

Fuel oil is obtained from tank cars on a siding alongside of the factory. A Viking oil pump, driven by a 5-hp. General Electric motor through a silent chain drive, pumps the oil to steel storage tanks located underground just outside of the engine room, about 160 ft. away from the siding. The tank for the engine fuel has a capacity of 10,000 gal. Steam coils heat the oil in the winter time. A two-way valve, located near the pump, permits the oil to be directed to either storage tank depending upon the kind being drawn from the tank car.

Day tanks are attached to each engine, the one for the 300-hp. unit has a capacity of 5 gal. The oil is pumped from the storage tank to the day tanks by pumps attached to the engines. The fuel oil flows by gravity from the day tanks to the engine cylinders where it is forced into the engine cylinders by the injection pumps.

City Water Used for Jacket Cooling

Make-up water for jacket cooling is taken directly from the city main and is not treated. Water enters the engine jacket at about 70 deg. F. and leaves it at 110 deg. It is pumped through the jackets by a 3-hp. Westinghouse motor driven Goulds centrifugal pump. One pump supplies circulation for all three engines. Provision is made for use of city water in emergency cases. From the jackets the water flows to the top of the cooling tower shown in Fig. 4. As shown, this is located in the rear of the factory just back of the engine room. After passing over the baffles in the tower, the water drains into the 15,000-gal. steel tank shown, from which it is drawn by the pumps for recirculation.

Combustion air for the smaller engines is taken from the upper part of the engine room; that for the 300-hp. engine is taken from outside of the engine room. No air filters are used, as there is little contamination of air in the vicinity of the factory.

Starting is accomplished by air compressed to 200-lb. pressure. The main compressor unit consists of a 4½ and 2 by 4½-in. Gardner-Denver air compressor running at 500 r.p.m., belt driven by a 7.5-hp. Crocker-Wheeler, direct-current motor running at 1750 r.p.m. An emergency drive consisting of an 8-hp. New Way model D.H. gasoline engine which can be readily belted to the air compressor is also provided.

The engine exhaust manifold is water jacketed and is attached to the cylinder heads in such a manner that any head can be removed without disturbing the setting of the manifold. The exhaust pipes run horizontally through the engine room wall to exhaust mufflers of the cast-iron pot type which are located on platforms just outside of the wall as shown in Fig. 4.

Convenient Plant Attractively Adorned

Neatness of appearance and convenience of attendance characterize the engine room which is 40 ft. wide by 60 ft. long. Ample day lighting is effected by the high lights shown in the headpiece of this article and by the ample window space on the opposite side of the room as illustrated in Fig. 4. Ample distribution of electric lights serves for night operation. The construction of the entire factory including the engine room is of brick with steel sash.

No vibration of the floor is perceptible, due to the unique construction of the engine foundation, all three of which are constructed in a single 6-ft. deep concrete block, to which there is no direct connection by the building or its foundation.

Minimum Attendance Cost

Supervision and attendance of the power plant is carried on in an unusual way. The former heating boilers had been coal fired. Substitution of boilers automatically oil fired, relieved the attendant of much of his labor so that, besides having another occasional duty in the factory, he is able to operate the plant during the daytime. During the night, the night watchman is ready to shut down the engines if an alarm sounds and to notify the chief electrician of the plant who supervises the operation of the power plant. In this way, it will

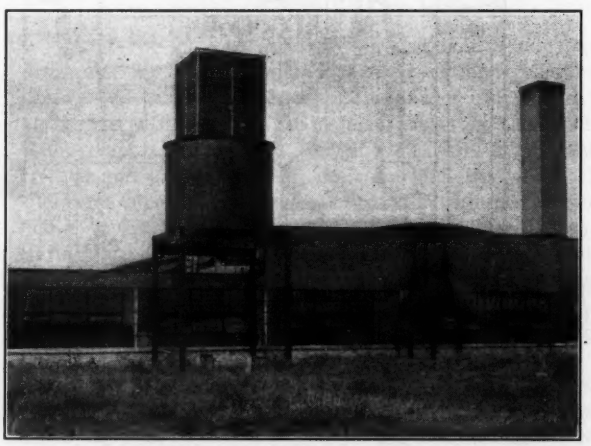


FIG. 4. EXTERIOR OF ENGINE ROOM SHOWING LOCATION OF COOLING WATER TANK AND COOLING TOWER

VESTA BATTERY CORPORATION - POWER DEPARTMENT REPORT

FOR WEEK ENDING MONDAY Aug 25 1930

	Labor in Hours			Fuel Oil Reading	Diesel Eng. Hours Operated			Diesel Oil Reading At Noon	K. W. Hour Reading At Noon	Lub. Oil Used Qts.	Lub. Oil Fltr Cl'd	Lub. Oil Circ. Cl'd	Fuel Oil Fltr. Cl'd	Pyrometer Readings Noon			
					#1	#2	#3							#1	#2	#3	#4
THURS.		12	6	47-INCH 5842 51310 GAL	24			38-INCH 3736	726000	8	2 PM	2 PM	2 PM	340	350	340	340
FRI.		12	6	46-INCH 5681 51440 GAL.	24			37-INCH 3606	728900	7	2 PM	2 PM	2 PM	350	340	340	340
SAT.		12	6	45-INCH 5520 51600 GAL	24			36-INCH 3472	730700	8	2 PM	2 PM	2 PM	340	310	330	320
SUN.	6	12	6	45-INCH 5520 51720 GAL.	24			34-INCH 3312	732100	7	2 PM	2 PM	2 PM	350	340	340	350
MON.		12	6	44-INCH 5361 51840 GAL	24			32-INCH 2986	734800	32	2 PM	2 PM	2 PM	350	320	320	320
TUES.		12	6	43-INCH 5200 51980 GAL	16		8	31-INCH 2828	736500	2							
TOTAL							8			2½							
										5	10 PM	10 PM	10 PM	340	320	320	340
										2½	2 PM	2 PM	2 PM				

FIG. 5. WEEKLY LOG SHEET GIVING OPERATION DATA

be seen that the power plant is operated without additional help.

Constant Attention Avoided by Alarm System

Two alarms are provided, one of which is for lubricating oil pressure. When the oil pressure drops to an unsafe point, a metal-gage needle makes a contact with a post on the dial of the oil gage, completing an electrical circuit which rings a bell. For the cooling-water circulation alarm, an industrial-type Mercoid control switch was installed which sounds an electric horn if the temperature of the water rises above 140 deg.

Switchboard construction is in unit-panels built by Marquette Electrical Switchboard Co. of Chicago. Its location is shown in the background of the headpiece. The Brown electric pyrometers which indicate the exhaust temperatures of the cylinders of all the engines are grouped together on the switchboard so as to facilitate the checking of these exhaust temperatures. The usual instruments as well as the Esterline-Angus graphic ammeter are also installed here and ground lights are provided.

Fuel Oil Consumption for Week 908 Cal.

Lubrication Oil Consumption for Week 74 Ct.

K. W. H. Output for Week 10500 K. W. Hrs.

Cost per K. W. H. at .05 for Fuel Oil 0.0043

Forced Shut Downs as Follows:

Time Reason

Repair parts or supplies used

Remarks

(Signed) Chas Ohlendorf

FIG. 6. REVERSE SIDE OF WEEKLY LOG SHEET

Simple Plant Record System

Because of the peculiar attendance condition and of direct and daily contact of the factory owners, the record system used, Fig. 5, is a daily instead of the usual hourly one. Printed on the reverse side of this weekly sheet is the form, Fig. 6. Both forms are mimeographed. Fuel consumption cost record is based on a rate of 5 cents as shown in Fig. 6. This is done to facilitate comparison and does not represent the actual cost which varies. At this rate the fuel cost is only $0.0043 per kw-hr.

During the entire operating period since the engines were started on June 10, 1929, there have been no forced shutdowns and no repairs. Grinding valves, attention to injection nozzles and renewal of several valve springs constituted the extent of replacement.

Economy Methods on Display

FIRING BOILERS is rapidly becoming a matter of brains rather than brawn. Not only do modern methods substitute machinery and power for human muscle in handling the fuel but automatic fuel and air control are replacing human watchfulness in the regulation of the firing. Even where automatic regulators are not used, remote control by the use of indicating and recording instruments, motor drive and control switches for fuel feed, air supply and water regulation are effecting economy and reducing labor. Six hundred motors in one power plant gives some idea of the extent of the development.

Other refinements are coming into power plants, especially as to wash rooms and sanitary facilities, which save space and make for better service. Control of water pressure and temperature insulation of heating and storage tanks, automatic temperature control at the radiator in each room are some of the advanced methods for saving energy of fuel.

Under present conditions, economies are eagerly sought, hence executives will be alert to study these advances as they will be demonstrated at the National Exposition of Power and Engineering in New York, Dec. 1 to 6.

There will be many displays of large full size equipment showing the application of latest automatic and remote control to operation. Exhibitors are showing special interest in arranging instructive exhibits, partly because they sense the opportunity to arouse the interest of those seeking new economies, partly because no exhibition will be held in New York in 1931.

AIR NECESSARY for the combustion of fuel can be calculated from the ultimate analysis of the fuel. In practice it is necessary to supply from 25 to 50 per cent more air than is theoretically necessary be supplied. There are two main reasons for this, the most important being that it is impossible to mix the oxygen of the air and the combustible gases in the furnace intimately enough in the limited time available, so that an excess of oxygen is supplied in order to speed up combustion. Sometimes excess air is supplied to cool the furnace either to prevent melting of the furnace walls or fusing of the ash.

Electricity---What It Is and How It Acts*

PART XLV. FURTHER CONSIDERATION OF THE VARIOUS TYPES OF MAGNETISM. THE THEORY OF PARA- AND FERROMAGNETISM. BY A. W. KRAMER

IN THE EXPLANATION of the theory of magnetism given in the preceding chapter, it was assumed that the gyroscopic forces due to the revolving electron were of a magnitude sufficient to maintain the direction of the system in opposition to the force of the applied magnetic field tending to reverse its direction. This assumption probably is not entirely correct and if a number of single revolving electrons were placed in a powerful

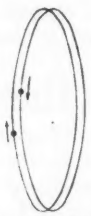


FIG. 1. DIAGRAM OF AN ATOM HAVING TWO ELECTRONS REVOLVING IN OPPOSITE DIRECTIONS. THE MAGNETIC FIELDS NEUTRALIZE EACH OTHER

magnetic field it is probable that the gyroscopic force would not be sufficient to enable them to retain their "opposite" direction.

Furthermore, in any diamagnetic body, the atoms and molecules are not merely single electronic systems but are complicated systems composed of many electronic orbits, many of which probably revolve in opposite directions. Such oppositely revolving electrons naturally will oppose each other insofar as their magnetic effect is concerned. Thus, if the number of electrons revolving in one direction in such an atom is balanced by an equal number revolving in an opposite direction, the resultant magnetic moment will be zero—that is, such an atom will exhibit no external magnetic moment and will, therefore, not be affected by an external magnetic field.

It must be obvious, however, that as regards the individual electronic orbits, the interaction of the magnetic moment of the electronic orbits with the magnetic field occurs whether the atom has a resultant magnetic moment or not. While the atom as a whole will be unaffected by the external field, the individual orbits will suffer a displacement dependent, of course, upon the mutual forces between the orbits themselves and the disturbing force. This displacement may be considered as somewhat analogous to the behavior of the electronic orbits in an atom of an electric insulator when placed in an electrostatic field. As shown in an earlier chapter[1] the orbits of electrons in an atom of insulating material undergo a displacement when placed in an electric field although the atom as a whole is not affected.

In a similar manner, we may assume that the electronic orbits of a magnetically neutral atom (one in which the magnetic moments of the electronic orbits neutralize each other) also undergo a displacement when placed in a magnetic field, although the atom itself is not acted upon by the field.

Consider the atom shown in Fig. 1, having two electrons revolving in opposite directions. Since their planes of rotation coincide, their magnetic moments are equal and opposite and therefore neutralize each other. Thus, this atom exhibits no external magnetic field.

Suppose now that a magnet is approached to the atom as indicated in Fig. 2. As was explained in the previous article, under these conditions, the speed of one of the electrons will be increased while the speed of the other (turning in the opposite direction) will be reduced. Thus, the magnetic moment of one will be increased while that of the other decreases. Now, it can be shown that the electron which has its speed increased is the one which points in a direction opposite to the imposed field.

Under these conditions, the two moments will not entirely neutralize each other, and there will be a resultant (external) magnetic field equal to the difference

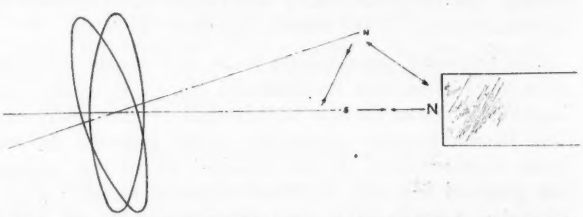


FIG. 2. SHOWING EFFECT OF AN EXTERNAL MAGNETIC FIELD UPON THE ATOM SHOWN IN FIG. 1. THE FIELD OF ONE IS STRENGTHENED WHILE THAT OF THE OTHER, DECREASED. AS A CONSEQUENCE, A DISPLACEMENT OCCURS

of the two moments. As shown in Fig. 2, the two orbits will be inclined toward one another, the one exhibiting north polarity at the north pole of the imposed magnet suffering the greatest inclination from the horizontal because of the increased repulsive force set up.

As depicted in Fig. 2, there is a repulsive force between N and N′ while between S and N′ the force is attractive. Originally, before the introduction of the magnet the forces N and S were equal but opposite in direction. The introduction of the magnet, however, has increased the strength of N while at the same time it has decreased the strength of S. Since N and S are opposite poles, however, there is an attraction between them and as N is deflected S will tend to follow to a certain extent. Gradually, as the amount of deflection increases, the repulsive force between N and N′ will be balanced by the attractive force between N and S, and further movement will cease.

This is perhaps a rather crude way of explaining it but at least it provides us with a picture of what might go on in an atom of a diamagnetic substance when it is placed in a magnetic field. It is evident that, in spite of the fact that such an atom has no external magnetic field, the electronic orbits themselves may be deflected.

*All rights reserved.

[1]Chapter X.

Under the combined action of the repulsive force of the magnet and the gyroscopic action described in the preceding chapter, the electronic orbit will undergo precession about an axis, passing through the nucleus.

Thus, it is seen, that in a diamagnetic material, while there may be a displacement of the electronic orbits within the atoms, the atom as a whole is not acted upon by the magnetic field. In other words, the atoms of a diamagnetic substance will undergo no rotation or movement when placed in a magnetic field. Consequently, since there is no motion of the atoms, the diamagnetic susceptibility[2] might be expected to be independent of the temperature. In an ordinary para- or ferromagnetic substance, the degree of magnetization of the body is dependent upon the temperature, since some of the rotational energy imparted to the atoms and molecules is lost in the collisions with neighboring systems. Since the magnetic state of a diamagnetic substance is not dependent upon any movement of the atom or molecule as a whole, it is evident that temperature (that is, the rate of vibration of the molecules) can have little or no effect.

And this has been shown to be a fact. P. Curie, in a series of investigations, found that for almost all of the diamagnetic substances investigated there was practically no change in the mass susceptibility with temperature.

Thus, the phenomenon of diamagnetism is due, fundamentally at least, to the fact that in the atom of a diamagnetic substance, the orbits are so disposed that their resultant effect is zero at points outside the atom.

Theory of Paramagnetism

For paramagnetic substances a different condition prevails. There it is assumed that the electronic orbits are such that the revolving electrons produce a resultant effect at points outside the atom, that is, the atom has a resultant magnetic moment. In other words, in an atom of a paramagnetic substance, the number of electrons revolving in one direction is not equal to that revolving in the opposite direction—therefore, a magnetic moment is produced, the magnitude of which is dependent upon the difference in number of oppositely revolving systems.

When an atom of this type is placed in a magnetic field, it is evident that it will be subjected to a force tending to turn it so that the direction of its magnetic axis alines itself with the direction of the field. The atom, therefore, will be subject to a rotational force as already explained.

When the atoms in a paramagnetic material are acted upon by a field in this manner, their free movement is impeded or restrained due to the mutual collision of the molecules. The amount of restraint, of course, is dependent not only upon the temperature of the substance but upon its physical state, i.e., whether a gas or a solid. In a gas the atoms, being spaced farther apart, are more free to turn than they are in a solid. In each case, however, the mutual collisions of the molecules will abstract some of the kinetic energy acquired from the impressed magnetic field, and will distribute it among the molecules in the form of kinetic energy of rotation about other axes and kinetic energy of translation. Consequently, the energy supplied to the substance (this applies particularly to a gas) by the impressed magnetic field will be partly converted into heat energy. A condition of equilibrium will be reached eventually, however, where the tendency for the molecules to set themselves with their magnetic axes in the direction of the magnetic field is balanced by the tendency of the molecular collisions to make them set themselves equally in all directions. When this point is reached, the conversion of the energy of the impressed magnetic field into heat energy will stop.

Ferromagnetism

So much for diamagnetic and paramagnetic materials. Now, what about ferromagnetic materials? Wherein do ferromagnetic materials which are very strongly magnetic differ from paramagnetics which are only weakly magnetic although otherwise of similar characteristics?

While a number of explanations have been offered, the matter is not clear and the behavior of ferromagnetics presents many difficulties when an attempt is made to account for their exact behavior on the basis of the electron theory. This need not lessen our belief in the correctness of the electron theory, for our inability to account for all the facts of ferromagnetic phenomena lies probably not in the incorrectness of the electron theory but in our ignorance of all the necessary facts. The main difficulty lies in the fact that at temperatures above the critical temperature, but well below the melting point, ferromagnetic substances become paramagnetic.

Naturally, the problem is one which has given rise to much speculation. The difference between paramagnetic and ferromagnetic substances may be accounted for by assuming a difference in the rotational kinetic energy of their respective molecules. In a paramagnetic substance, the molecules may be considered as endowed with a relatively large kinetic energy of rotation and that this produces a gyroscopic action which presents considerable resistance to their orientation by the impressed magnetic field. In the case of ferromagnetic substances below the critical point, we may assume that the rotational kinetic energy of the molecules is relatively small and as a consequence their resistance to orientation under the influence of the impressed magnetic field is small.

Thus, a substance with molecules of that kind is easily magnetized even by comparatively weak fields.

In these theories of magnetism, it is evident, much remains to be known, and it is quite possible, when more facts are discovered that our ideas on the subject will have to be modified considerably. At the present time, although much detailed knowledge concerning magnetism is known we have at best only a general understanding of the subject as a whole. Regardless of what the exact mechanism may be in the various classes of magnetic phenomena observable, it is quite evident that all of them have something to do with the rotation of electrons in the atoms. A current flowing in a closed ring sets up a magnetic field—that we know from actual experiment. Since a revolving electron is really an electric current also flowing in a closed ring, such an electron also will set up a magnetic field. This is the fundamental fact upon which all magnetic phenomena must be explained.

[2]By magnetic susceptibility is meant, the ratio of the intensity of magnetization to the magnetic field.

From the theory of magnetism here presented, it will be obvious why a ferromagnetic substance, such as iron, is so valuable in the construction of powerful electromagnets in engineering work. Any coil of wire through which a current flows produces within it a magnetic field. If twice as many turns are put on the coil or if the current is doubled, the magnetic field will be approximately twice as strong. In other words, the magnetic effects are added.

Now it will be evident that if we place within a solenoid a large number of little permanent magnets with their fields all disposed in the same direction, the effects of all the little magnets will be added to that of the solenoid. This is virtually what happens when a piece of iron is placed in a solenoid. As soon as the current is established, the field due to this current acts upon the molecular magnets of the iron so as to turn them all in the direction of the field of the solenoid itself. Thus, the field within the solenoid is very much stronger than it was before the iron was introduced.

For this reason, all electro-magnets and magnetic circuits such as are necessary in transformers and electric generators and motors are provided with iron or steel cores. The use of the iron core makes it possible to obtain magnetic intensities far in excess of anything that could be produced in air or other dia- or paramagnetic materials. It would be unfortunate, indeed, if nature had not provided us with ferromagnetic materials, for in the absence of such materials, electromagnetic equipment such as we have today would be unknown.

Problems Involved in Network Distribution

CONVERSION OF THREE-PHASE, THREE-WIRE TO THREE-PHASE, FOUR-WIRE SYSTEM. BY MAX A. FAUCETT* AND JOHN O. KRACHENBUEHL†

UTILITIES in the last few years have found it economical to increase the capacity of distribution systems by changing from the three-phase, three-wire distribution to a three-phase, four-wire distribution,

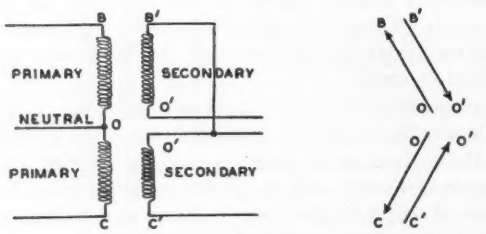


FIG. 1. ARRANGEMENT OF PRIMARIES AND SECONDARIES AND VECTOR RELATIONS OF TWO TRANSFORMERS IN NETWORK CONNECTION

adding the fourth wire and increasing the voltage between lines by 73 per cent. This conversion did not involve any special problems where the change was accomplished by connecting the primary from "Delta" to "Y," but did present a problem when the open delta bank of transformers was encountered.

In the case of the open delta bank of transformers it was necessary to connect the primary windings subtractive, thereby forming the connection known by the various names of "Incomplete Y," "Open Y," or "Network Connection." In this type of connection one of the secondary coils of the bank is reversed with respect to its primary. The trouble encountered with this type of connection always has been due to the fact that connections have been made on the assumption that the bank would operate and have characteristics similar to the open delta. This is not necessarily true, for an analysis of the connections will show that trouble may be experienced with the neutral wire if the system is operating near line capacity and the banks have not been rotated with respect to the primary lines, thereby reducing the current in the neutral.

The truth of the above statement may be readily demonstrated with a few simple vector diagrams. Figure 1 shows the vector relation of the primaries and secondaries of two transformers placed in "Network" connection. The assumption is that the ratio of transformation is 1:1 and the lettering is conventional and is not material so long as the proper vector sense in primary and secondary is chosen. Connecting this transformer

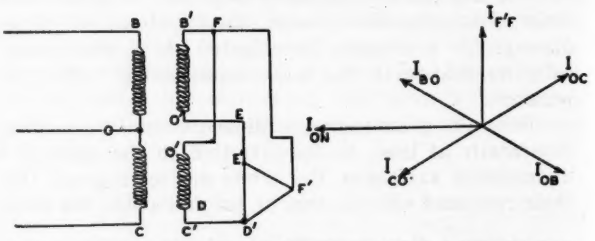


FIG. 2. TRANSFORMERS CONNECTED TO A 3 PHASE BALANCED LOAD TOGETHER WITH VECTOR RELATIONS OF CURRENTS

bank to a three-phase balanced load the condition shown in Fig. 2 exists.

The currents in lines EE', FF' and DD' will be equal in magnitude and displaced 120 electrical degrees. This secondary current is reflected back into the primary and the line currents are equal in the transformers. In the secondary system, the line currents are equal; in the primary system, the current in the neutral wire is not equal to the line current. From Fig. 2, it will be seen that the current in the neutral is the vector sum of the currents in the transformers, taken toward the neutral, expressed:

$$I_{ON} = I_{BO} + I_{CO}$$

From the geometry of the vector diagram, it will be seen that the primary neutral current is equal to 1.73 times the line current for a balanced load. It is probably due to this current condition that the neutral of the primary system fails under operating conditions. It is not uncommon practice to make the neutral wire the size of the line wires or even smaller, as in the case of the single-phase, three-wire distribution, but this may prove disastrous if a careful study of the load is not made.

If there are several installations of open delta transformers to be reconnected in the change over, it is well to see that the banks are rotated between the primary lines. This not only helps to balance the line currents but reduces the neutral current, for the current in the neutral lines of the different banks, properly arranged, will be displaced approximately 120 electrical degrees.

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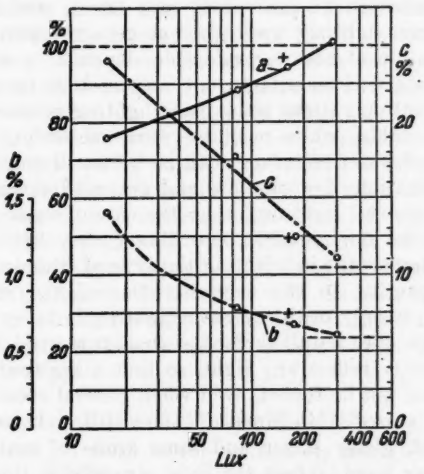
Factory and Workshop Lighting*

EFFICIENCY OF PRODUCTION DEPENDS TO A LARGE EXTENT UPON PROPER ILLUMINATION OF THE WORK. BY E. WITTIG†

THAT GOOD lighting in workshops is of commercial value is beyond dispute. The conviction is now general that illumination is of the same value in the shops as time and labor-saving devices or as lubricant for the motors. Scientific research and practical experience are consulted in this respect in order to create as far as possible the requisite conditions for the improvement of the quality of the goods and the increase of the output.



a = Output in % of that by daylight, *b* = Compositors errors in % of *a*, *c* = Letters reversed in % of *b*, ——— values for natural daylight (300 Lux), + values for artificial daylight (170 Lux) for *a*, *b* and *c*.

FIG. 1. INCREASE OF OUTPUT BY INCREASING THE ILLUMINATION. EXAMPLE FROM A PRINT WORKS

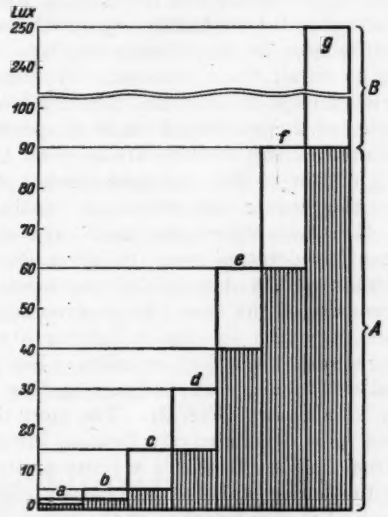
GENERAL LIGHTING CONSIDERATIONS

It is commonly known that the quantity and quality of the output of the night shift, particularly when the illumination is insufficient, is to a greater or lesser degree below that of the daytime.

This difference can be eliminated if care is taken to provide the best lighting conditions. There is scarcely a process which cannot be carried out quite as quickly and efficiently if the illumination is good.

True, it is necessary to free oneself from the habit of judging lighting installations by ordinary rule-of-thumb standards. The decisive factors are, after all, our organs of sight. When ill-treated by bad illumination or other equivalent causes, the eye becomes tired and the power of sight diminishes prematurely. This fatigue soon spreads to the body and the whole nervous system and leads to faulty work and waste, to reduced output, if not even to accidents. Since the eye is exceedingly adaptable and continues to function even under unfavorable conditions, the question of good illumination does not always receive the attention it deserves. The consequences are usually not noticeable at first, but often after a considerable time, the effects noted above are all the more severe. In consequence, the real reason is frequently not realized, viz.: the inadequacy of the illumination.

Since the eye is hardly suitable as a reliable arbiter —it is almost incapable of estimating light intensities with any degree of accuracy—certain measurable quantities have been adopted for the appraisement of the quality of lighting installations, quantities which have a favorable or unfavorable effect on the power of vision, such as: intensity of illumination, evenness, freedom from dazzle, degree of shadow formation.



a = Traffic lighting, *b* = Stores, *c* = Staircase, *d* = Smithy, *e* = Turning shop, *f* = Fine mechanic's shop, *g* = Watchmaker's shop, *A* = Insufficient illumination. *B* = Adequate illumination.

FIG. 2. REQUISITE ILLUMINATION FIGURES PROPOSED BY THE GERMAN SOCIETY FOR LIGHTING SCIENCE

The lighting intensity at each work bench or the average lighting intensity can be easily determined by handy measuring apparatus. Quite generally, an improvement in the illumination is followed by an improvement of the power of vision and consequently also of the capacity for work (Fig. 1). It is not until extremely high values of the lighting are attained—10,000 Lux[1] and more, such as are never met with in ordinary lighting practice—that this law becomes invalid in the above generalized form. Lesser lighting intensities are, of course, sufficient for rough work, while the increasing strain on the eye entailed by finer work necessitates an increase in the illumination. A guide to the strength of the illumination is furnished by the figures proposed by the German Society for the Science of Lighting, which, however, are only minimum values (Fig. 2).

*An abstract of an article in the Siemens Review.
†Siemens-Schuckert.

[1] 1 Lux = 1 Hefner candle per sq. meter, = approximately 12 ft. candles.

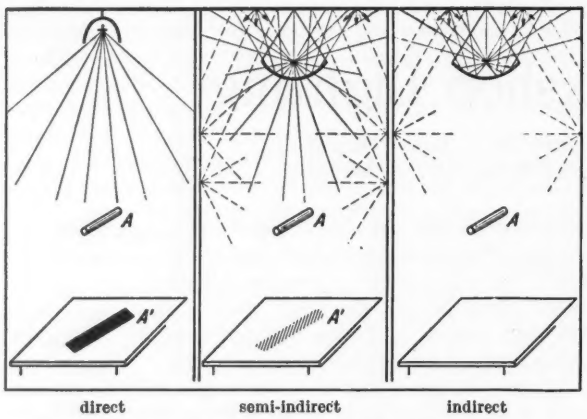


FIG. 3. THE THREE KINDS OF LIGHTING

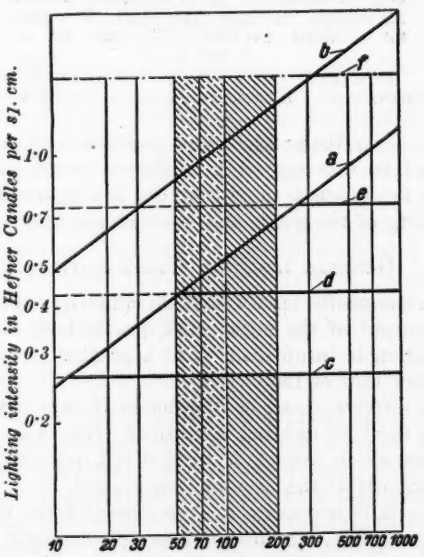
Depth of shadow when using a point like source of light corresponds to the degree of direct illumination.

Some attention should be paid to the evenness of the illumination. The eye, of course, is not very sensitive in this respect. Differences in the lighting intensity of the order of 1:3 to 1:4 are hardly perceptible to it. Too extreme differences in the illumination are, however, dangerous, above all when occasioned by cast shadows of moving machine parts and belts. The depth of shadow or the degree of shadow formation is of special importance. Whereas strong shadows are no great hindrance in a rolling mill or smithy, the same amount of shadow can appreciably reduce the volume and quality of the output in other shops where, say, small parts are turned on lathes. Consideration must be given in each individual instance to the type of lighting most suited to the requirements of the case. As is generally known, the shadows produced by direct lighting are sharply defined and strong, while they are more or less tempered by semi-indirect illumination; indirect lighting produces practically no shadows (Fig. 3). The most important requirement to be demanded of a lighting installation is freedom from dazzle. Dazzle is a waste of light, since it reduces the power of vision enormously and quickly tires the eye. Let care be taken at the outset, therefore, to use fittings which are free from glare and to adjust the lamps or arrange the fittings in such a manner that glare is eliminated. Dazzle is known to be caused by too intense contrasts between a dark background and brilliant, unshaded lamps or their reflection. When illuminating machines, etc., therefore the fittings should be so arranged that dazzle by reflection cannot occur.

A considerable influence on the type of lighting is exerted by the architectural style and decoration of the workshop to be illuminated, and—as already indicated—the class of work performed and the machinery used. In large machine erecting shops, the lighting fittings must be suspended at a considerable height on account of the traveling crane, although the light is required near the ground. In low shed-roofed buildings and low rooms, an endeavor is made to attain good even illumination with a limited number of lighting points, and fittings are therefore chosen which spread their light over a large surface. Since in both cases the simultaneous illumination of the ceiling and upper walls to any great extent would lead to considerable waste of light, owing to the absence of reflecting surfaces or excessive distance from the working plane, the best type of illumination for such rooms is one which is direct or predominantly so.

In multi-story buildings, which usually have low rooms which are—or easily can be—painted in light colors, indirect or semi-indirect lighting can be used instead of direct with the same justification. It is also always advisable to whiten the walls of large erecting shops and shed-roofed buildings, since this not only increases the efficiency of the illumination by utilization of the reflected light,—dark colors absorb the greater part of the light—but it creates better working conditions for the eye by avoiding excessive changes of brilliancy.

Whether in an individual case direct, semi-indirect or indirect lighting, work-place or general lighting or a combination of both is preferable, depends, in addition, on the class of manufacturers, inasmuch as in the case of manual operations work-place lighting is usually the most suitable, while machine work—according to the degree of automatization—can be better illuminated by a combination of work-place and general lighting or by purely general lighting, or, in the case of mass production on the moving table, by ordinary room lighting. It is also important in selecting the type of illumination to pay attention to the characteristics of the materials worked, if only ordinary room lighting is being chosen. Materials with a dull surface, such as raw wood, textiles, etc., hardly reflect any light, so that glare from reflection need not be feared, even when general room illumination is used. Machined or, more still, polished metal or wood, glossy paper and some kinds of textiles, on the other hand, reflect the light strongly so that it becomes essential, if direct lighting is employed, to exercise



a = Limit of dazzle for black reflection, *b* = Limit of dazzle for white reflection, *c* = Lucette 200 watts, *d* = Lucette 300 watts, *e* = Lucette 500 watts, *f* = Frosted lamp.

FIG. 4. LIMIT OF DAZZLE AS A FUNCTION OF THE INTENSITY OF THE SOURCE OF LIGHT AND THE ILLUMINATION, AS WELL AS REFLECTION OF THE BACKGROUND. LURETTES ARE GLASS LIGHTING FIXTURES MADE BY SIEMENS WHEREBY BY MEANS OF VARIOUS KINDS OF GLASS, VARIOUS KINDS OF LIGHT DISTRIBUTION ARE OBTAINED

great discretion in the location of the fittings so as to avoid reflections or to use indirect lighting, by means of which dazzle and reflection can be reduced to a minimum or eliminated.

Work-Place Lighting

As is only natural, very varied demands are placed on fittings for work-place lighting, depending on the uses to which they are put, and a corresponding variety of forms of these fittings has been developed. The feature common to them all is the small parabolic enameled reflector, which surrounds the lamp and prevents dazzle, in the first place, while at the same time concentrating the rays of light and directing them on to the work. Work-place fittings are as a rule provided with switches to enable the light to be switched on or off individually. In its simplest form the work-place fitting is provided with an eye for suspension from a hook. Suspension by means of a tubular or tough rubber pendant is more secure. The use of a single or double jointed arm increases the scope of use of the fitting. Other forms are wall-fittings, with or without joints, or arranged with swivel, hinged or telescope joints or a number of the same, with the help of which the fitting can be brought into such a position that the circle of light is thrown full on the work from the most favorable angle.

General Shop Illumination

For this purpose, larger fittings are used which are capable of taking the more powerful lamps necessary for the illumination of larger rooms. The presence of traveling cranes in foundries and other large shops compels the fittings to be arranged at a great height. Reflector fittings with deep parabolic enameled reflectors condense the light—presuming that the lamp is properly adjusted—in such an effective manner, that they efficiently light the ground floor even when suspended at considerable heights. The fitting of additional reflector fittings to the crane facilitates the work of the driver. These fittings are direct lighting fittings.

The so-called workshop fitting is provided with a shallow enameled reflector, which nevertheless completely covers the lamp, if properly adjusted, and is free from glare. In consequence of the wide angle of the reflector, this fitting is more dispersive than the previous one and thus has a wide sphere of utility in workshops with saw-tooth roofs and in low rooms, where the object is to illuminate large surfaces well and evenly from a moderate height.

For specially damp or steamy rooms, or such with an acid-laden atmosphere, the only fitting which can be used with perfect impunity is a porcelain fitting.

The types of fittings dealt with above give purely direct illumination, the characteristic of which is strong shadow formation, although this can to a certain extent be obviated by part-superimposition of the light circles thrown by each individual lamp. Generally speaking, the amount of shadow can be materially reduced by the use of semi-indirect lighting, i.e., by utilizing the reflection of large surfaces, such as color, and walls, which must, of course, be light in color. These conditions can best be fulfilled in multi-story buildings. The greater the component of indirect reflected light in proportion to the whole, the softer will be the shadows.

Totally indirect illumination is seldom used and only in special cases. This type of illumination is, of course, virtually shadowless and eliminates dazzle entirely, but the current consumption for adequate lighting is 30 to 40 per cent higher than for semi-indirect lighting, so that the latter form of illumination is generally preferred, if only on account of the current charges, if the type of manufacture should render the softening of the shadows important.

Some Aspects of Power Plant Safety

Mental Lapses, Oversights and Lack of Safety Mindedness Constitute Major Dangers; Some Odd Hazards That Take Their Toll; A Plea for a Greater Danger Sense. By I. L. Kentish-Rankin

DO YOU KNOW what it is to stand alongside a fellow worker, and have him struck down as he whistles while he works? Do you know what it means to stand beside a mangled form, to see his poor wrecked body, the agony on his face and the hopeless appeal in his pleading eyes? Have you ever knelt down before a man who knows he has only a few minutes to live and between his gasps hear him whisper, "Tell the boys to take care of mother," or have him ask you whether he is very badly hurt, whether he is going to die?

If you have known these things, you are a careful man. Hand in hand with carelessness travels death.

How many accidents occur annually in the power plants of the nation? Nobody knows. Last year 23,000 persons were killed in home accidents and nearly 3,500,000 more were injured in the home. Industry claimed 23,000 lives and injured 2,990,000 people last year, automobiles killed 31,000 and injured 1,000,000. Compared with these figures, the power house is probably one of the safest places in which to work. How safe or hazardous any power plant is, depends, primarily, upon the men in it.

What are the hazards of the power plant? Are they on account of high steam pressure, high temperatures, terrific peripheral speeds of turbine or due to the centrifugal force of large flywheels? Is high voltage and electric current the chief hazard or is it blood-poisoning due to infection or the danger of being hit on the head by a falling object? The majority of power plant accidents are the result of somebody's thoughtlessness or carelessness. It is not the failure of metals or mechanics, but the mental lapse of some man, the failure of some executive to take the necessary precautions when the installation was laid out on the drafting board, or forgetfulness of the foreman in telling his men to be careful, or the hurry-up job that causes men to put aside watchfulness and carefulness that a few minutes could be saved.

We all know death when we see it. We recognize torn and injured limbs and bodies when we see them. We comprehend pain and agony, perhaps pausing to realize how easily they might have been prevented. But how many of us see the conditions that lead to human suffering, so that they can be eliminated before they have the opportunity to take their awful toll? Do we know what we mean by safety—that it's so much more than a mere matter of construction or installation—because it is also a frame of mind that can be cultivated, developed and trained in a way that makes the man safe, that compels him to make his surrounding conditions safe so that he may be safe for himself and that he may make other men safe.

Study of power plant accidents will show that the greatest danger is where it is least suspected. There are surprisingly few accidents where high steam pressures and temperatures are involved. Men know the danger and they are careful in proportion. There are relatively few failures of structures, because manufacturers strive to deliver good material. It is the human failure, the mental lapse, distraction, the familiarity that breeds contempt of the old worker or the lack of training of the new worker, that cause the preponderance of accidents in the power house as well as in industry.

It has been said that the best safety appliance is a careful man. The time to start safety first is at the time a plant is laid out, followed by the proper installation. Engineers can use a suitable factor of safety in designing their pipes, flanges and turbine casings so as to guard against the unforeseen contingency. What the designer or manager cannot do is to have a factor of safety in judging his men. They must be protected, therefore, by necessary instructions, repeated reminders and the strictest rules rigidly enforced—all of these only after everything has been done to create safety as far as possible.

Launching the Drive Against Danger

In striving to excel, it is necessary to have a goal. In tackling the problem of danger, it is necessary to know what is dangerous and what is not dangerous. The man who goes out looking for dangers, faults, wastes and objectionable conditions is more likely to find them than the man who is not looking for them. This explains why the efficiency engineer is usually able to improve efficiencies materially by eliminating the small individual losses here and there. He is looking for things with which he can find fault, and so he finds them. The man looking for dangerous conditions also will find them. Just as it has been recommended that the individual consult his dentist twice a year and see his doctor at least every six months, so the executive in charge of the power plant should analyze his plant, his operating conditions and his personnel at least twice a year—analyzing them with the express purpose of finding fault, that improvement may come out of it.

In order to start somewhere, suppose that the dangers of the power plant are taken up one by one under these various classifications: Inherent hazards, permanent hazards, routine hazards, temporary hazards, indirect or byproduct hazards.

Inherent Hazards

This class of hazard is usually due to defective design or defective installation. For example, the engine throttle is so located that the engineer must risk his life in rushing to shut it off, in cases of emergency. To cite an instance, because a steam separator was improperly drained and the fireman maintained an excessively high water level, an engine was wrecked, blowing off the cylinder head at a time when the chief engineer and his assistant were both rushing to the throttle to shut the engine down. The cylinder head was blown off, hurled both men into the flywheel of another machine, killing them both. Here was an instance where an inherent hazard (the location of the engine throttle with respect to the cylinder head) together with the location of another engine, combined with a temporary hazard due to the combined effect of a high water level in the boiler together with a steam separator that was not properly drained.

Inherent hazards abound in many power plants. Absence of emergency exits; insufficient room between units; lack of railing, barriers and safeguards and insufficient room for the proper execution of repairs; inadequate illumination; absence of overspeed devices and electrically operated or chain-operated valves are typical instances of inherent hazards due to oversights in the design or at the time of installation or both.

Many needless accidents such as sprained ankles, fractured fingers, strained and wrenched backs, occur because of the wrong choice of flooring. There are places where the wooden platforms or the rubber mats are clearly indicated. At the same time, there are places where either of them may create a hazard due to moisture or sliding or because they constitute an obstruction. Steel flooring with the proper tread frequently eliminates certain classes of accidents.

Inherent hazards are frequently built into a power plant because the designer has in mind permanent, routine operating conditions and fails to take into consideration the emergencies and repairs that must be made. This is especially true where induced draft and economizers are used and where, in too many instances, no provision has been made whatsoever for quick replacements or safe working conditions. The steam piping of many plants is laid out with utter disregard of adequate drainage, overburdening the steam separators, increasing the danger from slugs of water being carried over into engine cylinders. The same is true of some condensers where danger of water being drawn up into the cylinders is always present when starting up.

Permanent Hazards

This type of hazard is differentiated from inherent hazards in that they can be remedied at any time, being due to commissions rather than omissions. For example, the laborer responsible for dumping coal from coal cars into the coal chute, from which it went to the coal crusher, was missing one night around 9:00 o'clock. His hat was found and as he had not punched the clock upon going off shift, search was made for him. He was never found but messy pieces of coal, bones and fabric told the story of how he had apparently been drawn through by the mass of avalanching coal, being first suffocated and then crushed by the coal crusher. Had the man been furnished with an iron rod to poke the coal and had the chute been provided with an adequate rack or grate, this man could never have been pulled down.

At the present time in one power plant, a permanent but inexcusable hazard exists, a hazard that should be obvious to everyone entering the plant. A concrete coal hopper of about 50-t. capacity, enables coal to be dumped into it from the sidewalk, by truck. Up to this time, never more than 25 or 30 t. of coal were kept in this bin. The bin is separated from the boiler room aisle by planks, placed one on top of another. The distance from these planks to the ashpit beneath the stoker is not more than 5 ft., not enough to enable the men to remove the ash efficiently. The ashpit is deep, about 6 ft. The planks holding back the coal in the bin are cracked. To look at them, one wonders when they will break entirely and the coal come avalanching down. Should this happen while a man was standing in front of the ashpit, he would be carried into the ashpit, probably to be cooked alive or terribly burned as the coal would close up the exit from the ashpit. One of these days, with the approach of cold weather or the threat of rising coal prices, will find that bin filled up with its 50 t. of coal. A neglected hazard will become a fatal catastrophe.

Recently a man in Chicago rolled from the top of a cinder pile into the machinery of the conveyor, being crushed to death. An inexpensive railing or rack would have prevented this accident. In another case, the steam jet ash conveyor blowing ash out into a vacant lot happened to be put into service while some boys innocently played within a range of the conveyor outlet. The result of the engineer failing to make sure that there was no one in danger resulted in costly litigation to his employer. Such accidents could not occur, were the man on the job, whether fireman or chief engineer, on the alert; or were he "sold" on safety.

The portable electric lamp cord may be truly looked upon as an inherent hazard. It is particularly deadly around the power plant, where steel structures and ash and moisture together with a ramification of water pipes constitute a permanent and low-resistance earth or ground. Men become covered with grime such as coal dust, mixed with perspiration so that their contact resistance is low. Under such circumstances, 110 v. is more than enough to kill. Notwithstanding the fact that danger of this cord is known, dozens of men are killed each year.

Every power plant has its permanent hazards, that exist only because somebody has not had the initiative or the alertness to abolish them. What is dangerous is expensive. The man who goes through his plant looking for these dangers will find them.

Routine Hazards

This type of hazard applies to any operation where mistakes of judgment may occur. Around the power plant, in particular, they are the dangers that result from climbing around to blow flues, to remove scale from tubes, cleaning surface condensers, with sand or slugs. They embrace the danger of falling objects, scaffolds that may break or turn over; stumbling over obstructions on the floor, defective steps or stairways and absence of adequate lighting. Lack of adequate illumination might strictly be listed under permanent hazards. The better the lighting, the fewer the accidents.

Every steam plant has a coal and ash-handling problem. But does every engineer in charge of a plant realize that every coal and ash-handling problem has its dangers? Surely enough tonnage of ash is handled weekly and has been handled for enough years to enable these hazards to be eliminated. Ashpits and ash tunnels are frequently laden with fumes which are injurious to both throat and lungs. While these fumes may not be serious enough to incapacitate a worker immediately, ultimately they are injurious, gradually but surely causing pulmonary troubles. Men who know what they are doing will not work in such places, but the low-paid foreigner does not know and cannot be expected to know. This type of hazard is not as conspicuous or spectacular as the explosion, but it is none the less real—and vastly less excusable. Adequate ventilation solves the problem.

Ashpit and ash tunnels below ground are not the only hazards in the handling of ash, however. Elevated ash storage tanks have their fatal accidents, therefore they call for eternal vigilance. Men have lost their lives in overhead ash tanks from suffocation, and asphyxiation and from being crushed to death or buried in the moving mass. The explosion hazard is also present. In many instances the ash becomes "frozen" and in order to break up this ash it is frequently necessary for one or more men to climb into the ash tank and cut through the ash with metal rods. When the ash commences to move, it is a simple matter for the man to be caught in the avalanche and either to be crushed to death or buried in the moving mass, to die from suffocation with or without the presence of dangerous fumes. No man should ever be sent into an overhead ash tank until it has been thoroughly ventilated. It is better that two men enter while one man stays outside. It would seem, further, that the men in the tanks should have ropes tied around their bodies so that their companion outside the tank can pull them out should they be overcome by gas or should they get caught and dragged down by the sliding ash. This type of accident does not occur every day but it has occurred too frequently.

Another type of accident in the overhead ash hopper is that due to explosion. Recently one man was killed and three others were seriously injured in Chicago. The hopper, about one story and a half in height, was built over a passageway so that ash could be dumped into the trucks as they passed beneath. The carbon content of the ash was high and due to the accumulation of gas an explosion occurred, taking its toll of one life and injuring three men.

Men handling ash in a furnace using powdered coal are face to face with a real, though perhaps rare type of hazard. In a Milwaukee plant recently, two men were wetting down ash preparatory to cleaning out the combustion space of a powdered coal furnace below a water-tube, horizontally baffled boiler without a bridge wall. When the water came in contact with the incandescent layer of coal particles beneath the ash, an explosion occurred, the flash of flame burning the two workmen quite severely. Apparently the explosion was due to water gas generated by the contact of the water with the incandescent layer of coal particles under the surface of the ash. It appears that a carload of coal different from that ordinarily burned, had been used.

It was rather difficult to burn, so that after about three weeks' operation it was found necessary to shut down and remove the ash, which remained as an incandescent mass. Here is a type of hazard which ordinarily would not be suspected. From now on, however, it is the type of hazard which every operator of a powdered coal plant should guard against.

Natural Gas, Oil and Powdered Coal Introduce New Hazards

Increasing use of natural gas and pulverized coal bring about additional hazards as well as explosion hazards. The same is true of fuel oil, though to a much lesser extent. Many men have been injured by explosion or the flame as the result of explosion because they entered a furnace or a storage bin before it had been adequately ventilated. The method used to start up a powdered coal installation is in many instances reckless. Fuel oil also creates dangerous fumes that may lurk in unsuspected places, to cause asphyxiation or explosion. The increasing use of natural gas may be expected to multiply this type of accident, unless men are on the alert to prevent it.

In August, 1929, the accident at Joliet that claimed the lives of five or more men with dangerous injury to more than half a dozen more, is still fresh in mind. Many such explosions have occurred in furnaces or in coal bunkers, so that today almost every operator in charge of a pulverized coal-burning plant is on the alert and knows how to combat this danger.

Another real danger connected with the pulverized coal plant that is ordinarily overlooked is due to gas-poisoning and asphyxiation. A number of men have lost their lives in plants burning powdered coal due to poisoning from carbon monoxide. Because this gas is extremely poisonous, yet odorless, it should be suspected in all storage bins and other closed places. Bins and other spaces should be thoroughly ventilated to eliminate the possibility of explosion and to remove whatever carbon monoxide gas may have collected, before men are allowed to enter these places.

Where work is to be done, an absolute aeration should be carried out before the men enter these spaces. Moreover, adequate ventilation should be maintained so long as the men are at work, using a forced draft blower if necessary. Conditions may exist where self-contained oxygen-breathing apparatus or a hose-mask should be supplied to each man, where there is doubt that adequate ventilation can be maintained. This is done on oil tankers and should also be done in some pulverized coal-burning plants. In other instances, it is advisable to station one man outside the bin so that he may watch the workers below and render help if necessary. A still further precaution is to tie a rope around each man's waist or beneath the arm pits so that he can be pulled out should he become unconscious. These precautions may not apply to every plant but every plant is a safer plant because such lurking dangers are suspected. The facts must be faced and facing them is the best way to remove them.

In regard to oil fuel, the fire hazard due to leakage and the explosion hazard due to the gases given off and held in close spaces, are well understood. Nevertheless, accidents are continuing to happen, even in some of the largest stations.

A typical instance occurred last April in a large eastern plant burning oil. Two boilers were served by one stack, the boilers having been out of service for some considerable time. In fact, mechanical type oil burners using light grades of fuel oil were being used to dry out these boilers, one boiler had been down for some 15 hr., the other boiler for about five days. When the men entered the stack to clean and apply a protective paint, a gas explosion occurred, notwithstanding the fact that no matches were struck, or no naked flame was observed. As the boiler surfaces were quite cool, the probable explanation is that the oil vapors condensed and so formed a gas pocket in the boiler outlet and in the boiler breeching. A spark from a man's shoe or possibly from the electric lamp ignited the gas pockets. The use of a small portable blower, if no other means of ventilation existed, would have eliminated this stagnant gas with possibilities to do damage and injury. This instance proves, however, that 15 hr. or even five days does not constitute sufficient lapse of time for gas to be driven off by natural ventilation. In many instances, the only way to dispose of these dangerous gases is by means of more ventilation.

Dangers of the Unexpected and Unsuspected

High steam pressures and temperatures, high speed resulting in centrifugal force either of turbine rotor or flywheel, suggest danger. Yet these dangers are not as great as those due to conditions that are unsuspected, such as have been mentioned above. Of course, flanges blow out, boiler tubes fail, cylinder heads blow off, engines or turbines run away or a valve explodes. Men forget to close the blowdown valve of a dead boiler and someone gets injured, when another boiler is blown down. These dangers are not the fault of the steam pressure or the heat but rest entirely upon the uncertainty of the human element.

The fact that accidents can happen from such vague, obvious, mysterious and unsuspected causes as have been referred to, only serves to emphasize the importance of going out and looking for these potential dangers. It is hoped that covering these may serve to give impetus to the cause of safety and to guarding against the unexpected and unsuspected while they may serve to imbue executives with a better understanding of the responsibility that is theirs and the real need for vigilance.

The moral obligation for safety rests with "the man upstairs" rather than the man down below. So, analyze your plant for hazards and lurking dangers. Search out the unsuspected and unlikely hazard, remembering that "prevention is better than cure."

Conductivity meters have been successfully applied to the measurement of entrainment of chemical salts from boiler and the concentration of boiler water. The accuracy of the method is said to equal that of chemical analysis when the concentration is high and greater than chemical analysis when the water is nearly pure. Corrections for CO_2 must be made, however, as CO_2 increases the conductance of the sample and its influence is particularly noticeable when the dissolved salts are low. With 2 p.p.m. of dissolved salts, 5 p.p.m. of CO_2 will increase the conductivity almost 50 per cent while with 10 p.p.m. of dissolved salts the increase due to 5 p.p.m. of CO_2 is only about 4 per cent.

Locating Unit Heaters in Industrial Buildings

By Proper Location of Unit Heaters, Certain Types of Buildings Can Be Adequately Heated Without Drafts and at Low Fuel Cost. Diagrams of Various Arrangements Show How This Is Done. By Charles L. Hubbard

EMPLOYMENT of unit heaters, particularly in industrial buildings, has become so common that both designing and operating engineers are familiar with their general construction and the more important details of installation. As so much depends upon the location of the units, it may be well to consider this matter briefly, especially as the type and form of building, its use, and the design of heater equipment employed all have an important bearing upon the number of units and their arrangement.

Function of the Unit Heater

The special field of the unit heater is in heating large spaces of considerable height, where it is difficult to maintain a comfortable temperature in the occupied zone without greatly overheating the upper part of the room. It is not uncommon in buildings heated by coils or radiators near the floor level, to have a temperature variation of 2 deg. or more per foot in height. This, for example, in a one-story building 20 ft. high, would amount to $20 \times 2 = 40$ deg. One of the chief advantages of the unit heater is its ability to hold down the temperature in the upper part of the room and place the heat near the floor where needed, thus reducing the transmission loss through the roof or ceiling, at the same time maintaining more comfortable conditions in the occupied zone.

If, by substituting unit heaters for direct radiation in the building referred to, the temperature variation could be reduced to 10 deg., then the temperature of the air next to the roof would be lowered $40 - 10 = 30$ deg.

A 3-in. concrete roof construction, with waterproofing, will have a transmission factor of about 0.6 B.t.u. per sq. ft. per degree difference per hour, so that cutting down the temperature of the upper air 30 deg. will reduce the heat loss through the roof $30 \times 0.6 = 18$ B.t.u. per sq. ft. per hr. For a building 60×250 ft., with monitor, this would amount to approximately 324,000 B.t.u. and result in the saving of about 36 lb. of coal per hour under average conditions.

Assuming a heating season of 28 weeks, with the plant in operation 44 hr. per week, the saving in fuel would amount to $(36 \times 44 \times 28) \div 2000 = 22$ t. per year for the assumed conditions.

Unit Heaters Tend to Reduce Air Leakage

Another source of heat loss caused by overheating the upper part of the building is that due to the outward leakage of warm air. The magnitude of this will of course depend upon the tightness of the roof construction, the number and size of windows in the monitor, and the type and fit of the sashes. Regardless of the area for leakage, the velocity of air flow through it will depend upon the flue effects of the building, which in turn is influenced by the temperature of the air within it for given outside conditions.

For example, in the building under consideration, assume a temperature of 60 deg. at the floor and 100 deg. at the roof, giving an average of 80 deg. when heated by direct radiation. Suppose the use of unit heaters cuts the temperature near the roof to 70 deg., in which case the average for the building will become 65 deg. Assume an average outside temperature of 35 deg. for the heating season. Then with an inside warm-air column 20 ft. in height, the theoretical velocity of the upward movement of the air in the first case will be $8 \sqrt{[20 \times (80 - 35) \div (460 + 35)]} = 10.8$ ft. per sec. and in the second,

$8 \sqrt{[20 \times (65 - 35) \div (460 + 35)]} = 8.8$ ft. per sec.

That is, the tendency to warm air leakage will be only $8.8 \div 10.8 = 0.8$ as great when the temperature of the building is equalized by the use of unit heaters as when it is allowed to build up beneath the roof.

Among other advantages of the unit heater may be mentioned low first cost, compactness, small number of units to be connected, as compared with direct radiation, non-interference with light and machinery.

As the capacity of the unit heater runs from 1000 to 2000 B.t.u. per square foot of surface per hour, as against about 240 B.t.u. for direct radiation, the amount of material is greatly reduced. Furthermore, the use of fins and various other extensions makes it possible to secure about 15 times as much heating surface per running foot as with plain piping, thus reducing both size and weight for a given heating capacity. As the complete outfit may be fabricated in the shop, except for the steam connections, the cost of labor for erection is reduced to a minimum. When compared with a central fan system, with distributing ducts, the latter are done away with, together with the frictional resistance which they introduce, thus reducing the work of the fan. While it is true that more mechanical units are required, they are of the simplest construction, propeller fans with direct-connected motors being largely employed for this purpose. It was formerly thought that the lower efficiency of this type of fan, as compared with the housed centrifugal, would increase the power requirements considerably over the older method with duct distribution, but with the open, low-resistance, heaters employed and the absence of distributing ducts, the propeller fan has proved to be more efficient.

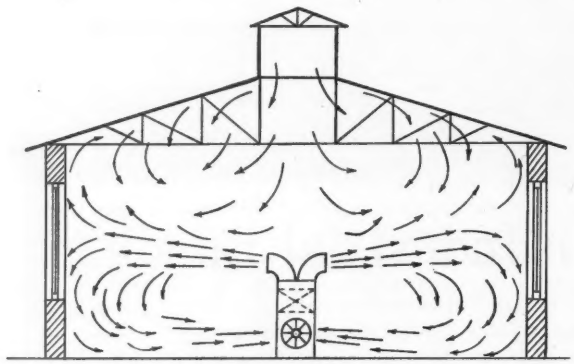


FIG. 1. IDEAL HEAT DISTRIBUTION APPROXIMATED BY USE OF UNIT HEATER

In a general way, there is little competition between the two systems and most of the manufacturers of centrifugal fans carry a line of unit heaters also for the class of work to which they are best adapted. When a number of smaller rooms is to be taken care of, the central system with distributing ducts, is usually recommended; for large open spaces, the unit heater is becoming the standard equipment in many cases.

Operation of the Unit Heater

The result sought with a heater of this type is to direct the air currents so as to give a slow movement to the entire air contents of the room, which will evenly distribute the warm air and return the cooler air to the heater without churning or the production of unpleasant drafts. The general method of securing this result is indicated approximately in Fig. 1, although various conditions may require modifications, as shown in the following illustrations.

In this general arrangement, the warm air is discharged horizontally, or nearly so, at a height of 8 or 10 ft. above the floor, with the result that the movement is confined largely to a stratum at the lower part of the room, where most needed by the occupants.

Any tendency of the warm air to rise will be largely overcome by the cooler air settling from contact with the cold roof and walls, thus lowering its temperature and causing the entire body to fall gradually as it returns to the heater along the floor.

In some cases it is necessary to deflect the warm air downward somewhat, in order to overcome its natural buoyancy and hold it to the desired level. This may be done by the use of adjustable outlets, deflecting vanes or by tilting the entire unit, according to the design used. The heater, shown in Fig. 1, is of the floor type. Others are made to be suspended from posts, walls, or overhead construction, according to local conditions.

Results, shown in Fig. 1, may also be approximated by the use of two overhead units, arranged as in Fig. 2, although there will be a greater tendency to short-circuiting in this case, with less effective heating at the floor.

Sometimes the arrangement in Fig. 1 is reversed and the warm air discharged at the bottom in the case of spaces in front of large outside doors or other locations where cold air has a tendency to settle along the lower part of the room.

This latter scheme, however, is not suitable for general use in textile mills, woodworking shops, or other industrial plants where there is lint or dust upon the floor in any amount, as the dust is likely to be disturbed and carried along with the air currents.

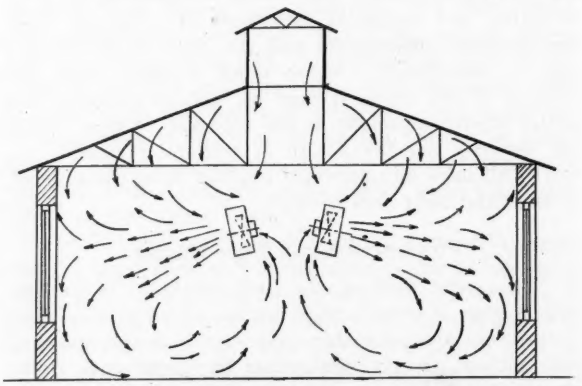


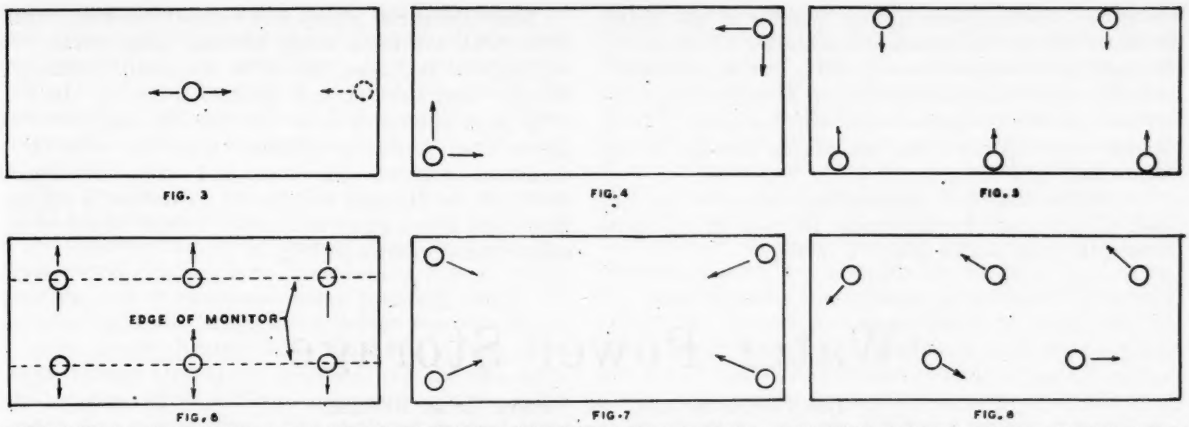
FIG. 2. ANOTHER METHOD OF SECURING RESULTS SHOWN IN FIG. 1

Gas-Fired Heaters

Thus far we have only mentioned heaters supplied with steam. In a number of large plants recently constructed, unit heaters have been employed for burning gas, thus doing away with the necessity of boilers and and leaving the basement free for manufacturing purposes. This arrangement, of course, is only adapted to cases where the low cost of gas makes this fuel possible and where electricity for power and lighting is purchased from a central station.

Gas heating units are especially designed for the circulation of air through them and the products of combustion are often discharged above the roof by special flues.

Floor area which can be warmed by a single unit heater varies with the size and number of outlets, the



FIGS. 3 TO 8. PLAN VIEWS OF VARIOUS TYPICAL ARRANGEMENTS OF UNIT HEATERS FOR PRODUCING CIRCULATION

Fig. 3—Location for a Single Unit. Fig. 4—Arrangement for Two Units. Fig. 5—Wall-type Units in Large Building. Fig. 6—Layout for a Monitor-roof Building. Fig. 7—Corner Arrangement. Fig. 8—Method of Creating Positive Rotation.

type of fan and kind of building in which it is used and commonly runs from 2000 to 10,000 sq. ft., although buildings having a floor area of 20,000 sq. ft. have been successfully warmed by a single unit. The distance to which warm air currents can be directed from the discharge outlets will vary with the type and design of the equipment and should be fixed by the manufacturer in each case. One of the later units, employing a propeller fan, discharges the air at an initial velocity of 1000 to 1800 ft. per min. and when located at an elevation of 18 to 20 ft. is designed to displace cool air forcibly from near the floor at a distance of 50 ft. from the discharge outlet.

The general air movement indicated in Figs. 1 and 2 is sought in most cases where the location of the heating units will permit it. The initial direction of discharge will necessarily vary, depending upon the required elevation of the unit and in practice runs from horizontal to vertically downward in some cases. Any arrangement which draws its return air from near the floor and tends to keep the entire air contents of the room in slow motion, as in Figs. 1 and 2, will hold the greater part of the heat in the occupied zone, keep the floor warm and produce a minimum of draftiness. In some locations it is necessary to place the units so as to blow the warm air directly downward, or nearly so, in which case special diffusers should be employed to break up the currents and prevent drafts upon those working below. The floor-type unit commonly draws its air from near the floor and the same result may be obtained with the wall or overhead type by carrying down a return duct. In many cases satisfactory results are obtained without this when the warm air discharge is properly directed, although there is likely to be more or less short-circuiting, as already mentioned in connection with Fig. 2, when this is done.

Unit Heaters Permit Wide Variety of Arrangement

Such a variety of arrangements are employed that only a few representative ones can be shown in the present case.

For a building within the capacity of a single unit, the arrangement shown in Fig. 3 may be used, although satisfactory results are sometimes obtained by placing the heater at one end of the room, as shown dotted at the right. For larger spaces, Fig. 4 gives good results, in which the warm air is blown along the outer walls. Other arrangements for two heaters would be to place a unit in the center of the building, at each end, discharging towards each another. If the building were not too wide, the heaters could be located on one wall to blow the air across toward the other. A double arrangement of this kind for a wider building is illustrated in Fig. 5.

One of the most satisfactory plans for a one-story

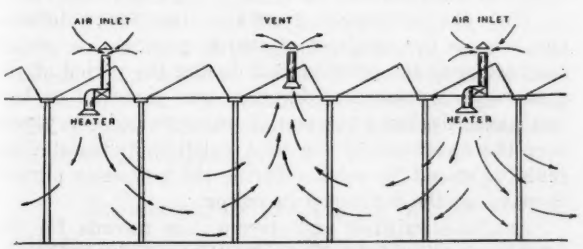


FIG. 9. HEATING AND VENTILATING ARRANGEMENT FOR A ONE-STORY BUILDING WITH SAW-TOOTH ROOF

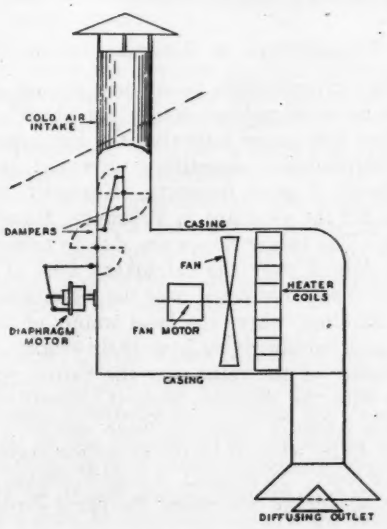


FIG. 10. DETAIL OF ONE OF THE HEATERS SHOWN IN FIG. 9

industrial building, with a large monitor in the center, is shown in Fig. 6, in which case heaters are mounted on the posts and designed as to discharge warm air toward both the outer walls and the center, as indicated by the arrows. In still another arrangement, heaters are placed in each corner of the room, discharging toward the center, as in Fig. 7.

A scheme employed for rotating the entire air content of the room, by delivering the jets at an angle toward the outer walls, is shown in Fig. 8.

Many industrial plants make use of one-story structures, with saw-tooth roofs, covering large areas. In buildings of this type, the air is frequently discharged directly downward through suitable diffusers. In Fig. 9 the arrangement is such that the air may either be drawn from outside or rotated within the building, as conditions require. Air inlets and vents alternate as shown in the drawing and the air movement is approximately as indicated by the arrows. Detail of one of the heater units is shown in Fig. 10.

Water Power Storage*

Developments Made on Santee River System, Having 15,000 Sq. Mi. Drainage. By W. S. Lee**

DURING THE PAST three decades, as large power groups have been developed by interlinking and thereby building up a larger power load, it has been possible to utilize variable flow streams to the fullest extent. The larger the system becomes, the more diversified the load and the better can use be made of the water power resources in combination with steam power. To develop these features to the utmost, it is often possible to superimpose over the whole hydraulic system reservoirs of large capacity which store the season high water flow and release large quantities of water during extended periods of low-water flow.

Santee River System

One of these systems is now operating in the Carolinas, serving a territory of approximately 300 by 150 mi. as shown on the accompanying map.

The Santee River drains an area of a little more than 15,000 sq. mi., its principal tributaries being the Catawba River, called Wateree River in South Carolina, 5225 sq. mi., Broad River, 5200 sq. mi., Saluda River, 2350 sq. mi. Below the junction of the Broad and Saluda rivers, the stream is called the Congaree and this with the Wateree form the Santee River, which finally discharges into the Atlantic Ocean.

Distribution of Rainfall and Runoff

In this river system no natural storage is available, there is no snow melting season but periods of extreme low water flow occur following the hot summer months and precipitations, sometimes torrential in character, cause floods of great intensity. Normally, the peaks of rainfall for the year are in February, March, July and August. The larger floods are due to tropical cyclones moving inland over the catchment area of the system and then being dissipated over the mountains of western North Carolina, where the head waters of the Catawba, Broad and Saluda rivers have their origin.

Intensity of the rains over the Santee watershed increases with the distance from the mouth of the river. Near the Atlantic coast the mean annual precipitation is about 45 in. whereas in the mountain region it reaches 75 in. or more. In general, it may be stated that, before the use of storage reservoirs, the three main tributaries of the Santee River were subject to such frequent and marked changes in volume as were probably nowhere else found in the United States.

Initial Hydroelectric Station

Pioneer in the development of the Santee River water power was the Catawba Power Co., which in 1904 began operation of a 6600-kv-a. development on the Catawba River, 18 mi. south of Charlotte, North Carolina. The plant operated under a head of 23 ft. with a pond formed by the dam large enough to store the night and Sunday flow of the river under average conditions. At that time, many cotton mills had their own steam power plants and it was possible to sell intermittent or secondary power, which was cut off in periods of low-water flow.

To keep step with the rapid growth of the cotton mill industry, three more "run-of-the-river" plants of 82,500 kv-a. aggregate capacity were built in the four years beginning 1906, two located on the Catawba River below the Catawba station and the Ninety-Nine Islands station on the Broad River, so as to have one plant on a stream of slightly different characteristics.

So far, it was customary to fix the installation of a plant to correspond to approximately the six months' average flow of the river but, with the demonstration of economy and reliability of the central station service to the industry, demand for secondary power fell off. To remedy this condition, four steam power stations, located at centers of large consumption of power, were built and placed in operation during the years 1911 to 1915, their aggregate capacity being 38,500 kv-a.

Storage Reservoir at Head of Existing Plants on Catawba River, Versus High-Head Developments

With the continuous growth of the power demand and because the unit cost of energy generated by steam mounted with the price of coal during the period of the great war, serious consideration was given as to how and where the large volumes of water wasted every year over the spillways of the then existing hydro stations could be stored for release during the low-water periods to make up the deficiency in power.

Available rainfall and stream flow records for the catchment area of the Catawba River showed that the intensity of runoff is greatest in the mountain region.

*From a paper before the World Power Conference, Berlin, June, 1930.

**Duke Power Co.

Since topography permitted either small reservoirs on some of the mountain streams to form part of high head developments, or one large reservoir so situated as to store the bulk of the flow of the head waters of the Catawba River for release to downstream hydro stations, comparative studies were made as to the merits of these two schemes.

The requirement was that a large block of power should be delivered during the periods of low-water flow of the Catawba and Broad rivers. High head developments would require long tunnels and flumes, which made the cost of produced energy relatively high. On the other hand, the Bridgewater storage reservoir would be conveniently located with reference to the three hydro stations already in operation and the two additional stations of 60,300-kv-a. aggregate capacity under construction at that time. The combined head of these five hydro stations was 281 ft. and, if the remainder of the plants on this same stream, which were built after the completion of the Bridgewater reservoir, is included, it would be 654 ft.

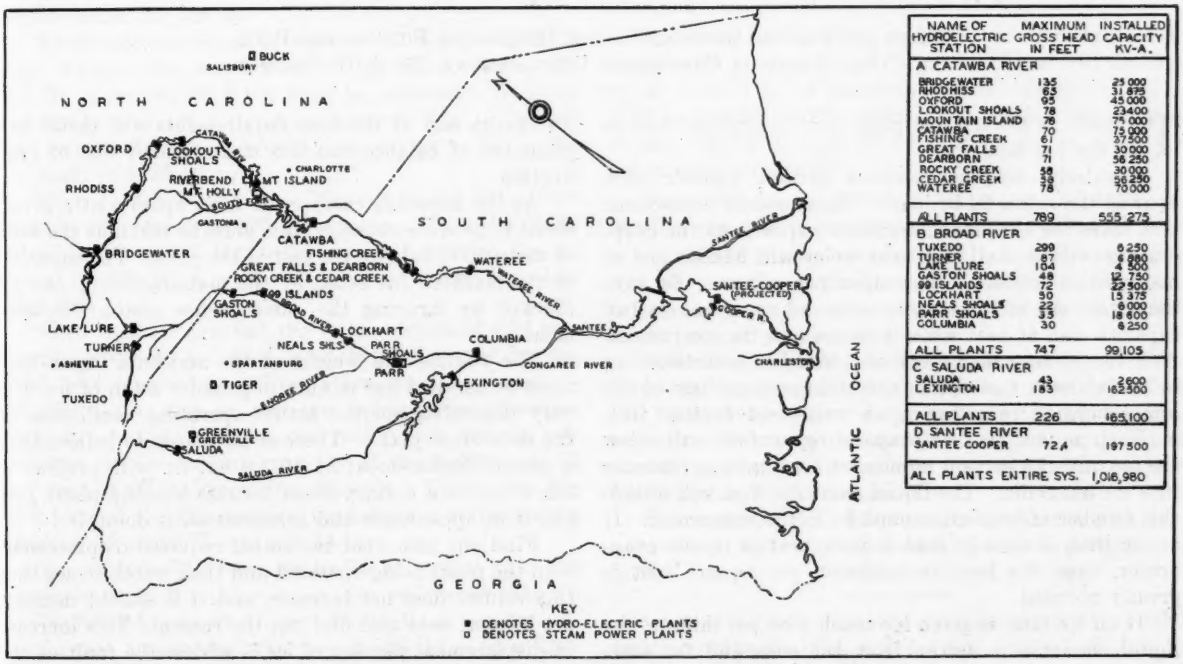
With this scheme the bed of the Catawba River itself could be used as the means to convey the released water from storage in successive stages to each of the eleven hydro stations located below the reservoir.

Available storage capacity of the Bridgewater Reservoir is 12.5 billion cubic feet corresponding to approximately 50 per cent of the annual inflow of the river at that point in a medium wet year. The map shows storage reservoirs and interconnected power systems in the region of Santee River and the table a list of the stations, their heads and capacities.

Reconstruction of Catawba Station

While formerly a part of the generating equipment at Catawba Station was standing idle during the periods of low water, conditions had changed entirely. Due to the more uniform flow of the river, more or less water was being wasted over the spillway continuously, in spite of the operation of this plant at a high load factor. In addition, the South Fork of the Catawba River joined the stream about 10 mi. above the Catawba station. By a reconstruction of the plant to increase the head to 70 ft., adding 47.6 ft. in height to the old spillway, was created another reservoir of 10.3 billion cu. ft. available storage capacity, available not only for the new Catawba station but also for the existing stations on the lower Catawba River having a combined gross head of 268 ft. It was found economical to scrap the old power plant representing a value of approximately one and a half million dollars and to build a modern hydroelectric station with an installed capacity of 75,000 kv-a.

In summer, 1925, the Piedmont section of the Carolinas suffered from the severest drought on record, so that the storage capacity of the reservoirs on the Santee River system was completely exhausted. To insure against the recurrence of such a condition the Duke Power Co., owning and operating all the hydro plants on the Catawba River, immediately proceeded with the construction of a modern steam power station of 70,000-kw. capacity, designed to operate continuously and intended to supply a constant amount of power; it should therefore be termed a "base plant."



NAME OF HYDROELECTRIC STATION	MAXIMUM GROSS HEAD IN FEET	INSTALLED CAPACITY KV-A.
A CATAWBA RIVER		
BRIDGEWATER	135	25 000
RHODHISS	65	31 875
OXFORD	95	45 000
LOOKOUT SHOALS	78	23400
MOUNTAIN ISLAND	78	75 000
CATAWBA	70	75 000
FISHING CREEK	61	37 500
GREAT FALLS	71	30 000
DEARBORN	71	56 250
ROCKY CREEK	48	30 000
CEDAR CREEK	48	56 250
WATEREE	78	70 000
ALL PLANTS	789	555 275
B BROAD RIVER		
TUXEDO	290	6 250
TURNER	87	6 250
LAKE LURE	104	4 500
GASTON SHOALS	48	12 750
99 ISLANDS	72	22 500
LOCKHART	90	13 375
NEALS SHOALS	22	6 000
PARR SHOALS	33	18 600
COLUMBIA	30	6 250
ALL PLANTS	747	99,105
C SALUDA RIVER		
SALUDA	43	2600
LEXINGTON	183	162500
ALL PLANTS	226	165,100
D SANTEE RIVER		
SANTEE COOPER	72.4	197500
ALL PLANTS ENTIRE SYS.		1,018,980

SANTEE RIVER SYSTEM STORAGE AND POWER PLANTS

Impounding Entire Flow of Saluda River

Next the principal power groups operating in the Carolinas became interested in a project for large water power storage on the Saluda River, the object being to generate five times as much power during the six months of low inflow as during the six months of high inflow, or, in other words, to superimpose a large amount of energy on the existing power systems at a time when the individual groups were unable to supply the demand

from their own central stations. A dam of 208 ft. height above the riverbed is now being completed on the Saluda River about 10 mi. west of the City of Columbia, S. C., to impound the entire flow of this stream. When full, the lake will have a superficial area of 76 sq. mi. with estimated available storage capacity of 78 billion cu. ft. The present station installation is 162,500 kv-a. with provision for increase to 243,750 kv-a.

It may be easily understood that the effect of this vast storage provided on the Catawba-Wateree River and on the Saluda River is now greatly noticeable on the Santee River, which carries all these waters to the sea. Plans are, therefore, now being worked out calling for the utilization of this regulated flow for the generation of power. Two large reservoirs connected by a canal are to be formed in the swampy lands of the Santee basin. The power station is to have an installation of 197,500 kv-a. operating under a maximum head of 72.4 ft., the tailrace discharging into an estuary arm of the Cooper River about 30 mi. north of the City of Charleston.

To develop such a storage system, it is usually necessary that there be central ownership of the various properties or a close understanding and operating arrangement between them. Usually these reservoirs are so expensive that one or two plants on a system cannot afford to build them. They are economical and possible when all power developments along the drainage area can join in the cost of building and operating them.

Securing Balance in the Operation of Ice Plants

FACTS AND FIGURES SHOWING PROPER METHOD OF FILLING AND PULLING CANS. AMMONIA COMPRESSOR DISPLACEMENT. BY A. G. SOLOMON

THERE IS ONLY one right way to pull ice and to fill the ice cans:

Regularly—by the clock—a certain number each hour of the entire 24-hr. day. The ammonia compressor that takes the heat laden ammonia vapor from the evaporating coils or shell and tube cooler will handle just so many cubic inches of this vapor per minute. Be sure that every one of these cubic inches of vapor has its full capacity load of heat when it passes into the compressor. And also be sure that every heat unit has been taken up in useful work and not in the attempted cooling of the atmosphere surrounding some uncovered suction line.

Each square foot of evaporating surface will allow the passing of a certain number of heat units per minute into the ammonia. The liquid ammonia that will absorb this number of heat units must be in the evaporator. If vapor that is already loaded with heat is in the evaporator, then the heat transmission per square foot is greatly reduced.

If an ice tank is given too much heat per minute, the liquid ammonia is driven from the coils and for some length of time the coils contain vapor or gas that will not take up heat. This causes the temperature of the brine to rise and slows down on the freezing of the ice. Uniform temperature must be maintained at all times.

Next comes the ammonia condenser. This has been designed to remove a certain number of heat units per minute.

If the ice tank is overloaded and there is a sudden taking up of excess heat units, in a short time the water flowing over the condenser cannot handle the overload. This results in high condenser pressure, heating of the liquid before it reaches the expansion valve, uncondensed ammonia passing into the evaporator and a loss in power that is required to do the unnecessary work.

WHY ICE MUST BE PULLED AT AN EVEN RATE

Now let us follow out our line of reasoning as to why the ice must be pulled at an even rate throughout the 24-hr. day. The water in the ice cans will require just so many hours to become solid ice at a certain temperature. To obtain best results in the plant, the regular routine must be followed out on a strictly time basis. To change any of the time requirements will throw the plant out of balance and this means added cost of production.

As the ammonia compressor must operate at a given speed to produce capacity, this must be taken as the unit of measure to balance the rest of the plant. The capacity of the machine (as rated by the manufacturer) can be checked by figuring the cubic inches piston displacement.

The volume and weight of the ammonia vapor that must be handled per minute to produce a ton of ice will vary depending on the actual operating conditions of the individual plant. There is no reason to believe that a piston displacement of 10,000 cu. in. will produce a ton of ice in a certain plant because another plant just like it in appearance and construction is doing it.

Find out just what the actual required displacement is in the plant being operated and then watch to see that this volume does not increase, and if it should increase get busy at once and find out the reason. This increase in displacement per ton of ice is seldom the fault of the ammonia compressor itself.

Some part of the system is out of balance owing to some neglect or slip in the operation. To keep the plant balance so as to produce capacity at a proper cost, every part of the plant must handle heat units at the same rate as the compressor handles the heat units contained in the ammonia vapor.

This means nothing more or less than that ice pulling and can filling must be done in a manner so as to keep from either overloading or underloading. Ice pulling must be regular.

We will consider a plant having a rated ice making capacity of 40 tons per 24 hr. The ice tank will contain 600 300-lb. cans. By pulling 266 blocks every 24 hr., we shall have 39.9 tons of ice.

We must bear in mind, however, that to produce this amount of actual ice we are putting more heat in the ice tank that what is contained in 39.9 tons of water. First, each block of ice will weigh about 310 lb. This adds 10 lb. to each can filled and will amount to 2660 lb. of water during 24 hr. Then the cores are sucked and filled. This adds not less than 15 lb. to each can or a

total of 3990 lb. in 24 hr. (allowing 15 lb. core water to each can is a fair average for most plants, but many plants use between 20 and 25 lb.).

Next consider the ice cans themselves. Each can will weigh about 75 lb. and this 75 lb. of metal goes into the tank at about the same temperature as the atmosphere above the ice tank. Call this 80 degrees in summer weather.

Method of Calculating the Heat Put Into Ice Tank

Now let us see just what heat we really put into the ice tank to be able to send one 300-lb. block of ice to the ice vault.

Water—325 lb.; this water will have an initial temperature of 80 deg. and must be made into ice having a temperature of 14 deg. Then 80 — 32 = 48 deg. to lower to freezing temperature. (Specific heat of water = 1.) This represents 48 B.t.u. per pound of water, or 15,600 B.t.u. for 325 lb.

To change one pound of water at 32 deg. to ice at 32 deg. requires the withdrawal of 144 B.t.u. Then, for 325 lb. of ice, 46,800 B.t.u. must be removed. To lower the temperature of 1 lb. of ice from 32 deg. to 14 deg. will require 9 B.t.u. (Specific heat of ice = 0.5.) 325 lb. requires 2925 B.t.u.

Then 15,600 + 46,800 + 2925 = 65,325 B.t.u. that must be removed from 325 lb. of water. To cool a 75-lb. metal can from 80 deg. to 14 deg. will require the removal of 225 B.t.u. (Specific heat of metal little less than 0.05.)

Then each ice can and the water contained will represent 65,550 B.t.u. As 6⅔ blocks = 1 ton of ice the total heat removed to deliver 1 ton ice to ice vault = 437,000 B.t.u. and as one ton refrigerating machine capacity = 288,000 B.t.u. we readily see that in our problem the ice making capacity of the machine is 52 per cent of the refrigerating capacity. To produce the 39.9 tons of ice, the machine must have a refrigerating capacity of about 77 tons per 24 hr.

To produce 39.9 tons ice in 24 hr. means that the ammonia going through the ice tank coils must take up 17,436,300 B.t.u. in 24 hr., or 726,512 B.t.u. per hr.

As each ice can and water = 65,550 B.t.u. then 726,512 ÷ 65,550 = 11.08 which is the correct number of cans to pull and fill each hour of the 24-hr. day. To pull the ice in this way means that 10 blocks and 12 blocks will be pulled alternate hours, leaving 2 blocks to be pulled at the end of the day to make a total of 266 blocks, or 39.9 tons.

This method of pulling ice and filling cans will keep the plant balance correct and will make it possible to maintain a constant brine temperature of 14 to 15 deg. Loss of ammonia at the rods will be reduced to its lowest as the temperature and state of the ammonia vapor will be the same at all times.

Ammonia Compressor Displacement, Figured on Heat Unit Basis

After the ammonia has taken its load of heat units from the water and cans in the ice tank, it goes to the ammonia compressor to have its pressure raised so that it can be changed back to liquid in the ammonia condenser where it gives up its heat to the condensing water.

The ammonia compressor must have sufficient piston displacement to handle the volume of vapor necessary to carry the collected heat from the ice tank to the condenser.

In our problem, let us assume the system to be operated at 25 lb. suction or evaporator pressure and 190 lb. condenser pressure. The temperatures that correspond to these pressures are 11 deg. and 98 deg.

Under these conditions, the refrigerating effect of one pound ammonia is 462 B.t.u. which means that each pound of ammonia circulated is capable of carrying 462 heat units in useful work.

We figured that to produce 39.9 tons ice in 24 hr. it was necessary to remove 17,436,300 B.t.u.

Now divide 17,436,300 by 462 = 37,741 lb. ammonia which is the weight of the ammonia circulated in 24 hr. to produce 39.9 tons ice.

One pound ammonia under our conditions will occupy 7.11 cu. ft. Then 37,741 × 7.11 = 268,338 cu. ft. of vapor.

Divide 37,741 by 39.9 = 946 lb. of ammonia circulated in 24 hr. per ton of ice made. Then 946 divided by 24 = 39.4 lb. of ammonia per hr. 39.4 × 7.11 × 1728 = 484,071 cu. ft. ammonia vapor per hr. per ton of ice. Divide 484,071 by 60 = 8068 cu. in. ammonia per minute per ton ice.

This 8068 cu. in. is the actual volume of ammonia handled per min. to produce 39.9 tons of ice in 24 hr.

As the efficiency of the ammonia compressor is 75 per cent, the compressor displacement must be 10,757 cu. in. per min. per ton, or a total displacement of 429,204 cu. in. per min. to produce 39.9 tons.

A horizontal double-acting machine, having 2 cylinders, 9-in. bore and 16-in. stroke running at a speed of 120 r.p.m. has a piston displacement of 476,520 cu. in. per min. The required displacement for our problem plus 10 per cent allowance for leakage is 429,204 plus 42,920 equals 472,124 cu. in.

This machine will balance almost exactly with our ice pulling and will allow a very small margin for surety.

Cast-iron pipes were first used for American public water supplies in 1804, a few years before their use in London, according to Chanute in a paper presented before the American Society of Civil Engineers over 50 yr. ago. Previous to that time, both in the United States and Europe, wooden pipes were used. In fact, the first water works steam engine used in Philadelphia in 1800 was constructed partially of wood as was the boiler itself. The duty was reported as 4,790,000 ft-lb. per 100 lb. of coal.

In 1804 steam pumping engines were added to the New York water supply which had been started about 5 yr. earlier. Apparently Boston, about 1652, with gravity water from springs, was the first town in America with a public water supply. It was over 100 years later, in 1754, that machinery was first used in this connection. This was at Bethlehem, Pa., where spring water was pumped by a lignum vitae pump with a 5-in. bore through hemlock wood pipes to a reservoir.

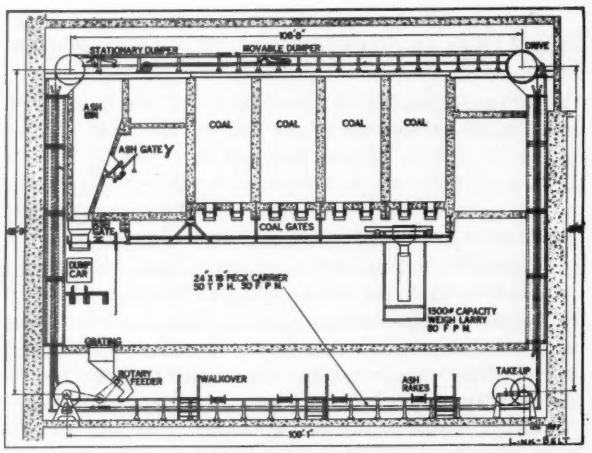
This pump was replaced after 8 yr. with three 4-in. bore 18-in. stroke pumps which were in service for 17 yr. The next pumps were probably those at Providence, R. I., in 1772 and Morristown, N. J., in 1791. By 1800 the total number of water supply systems numbered 16.

Coal and Ash Handling, Chicago Board of Trade Building

LOAD of about 1600 hp. is carried by four Stirling boilers and one Kewanee boiler. Two or three boilers operate regularly, using the Kewanee 150-hp. for summer.

Some 40 t. of 2-in. Franklin County screenings are burned a day by the Laclede stokers, making a problem to get coal to and ash from the furnaces.

The illustration shows the Link-Belt Peck Carrier system, which combines two conveyors in one, for handling both coal and ash. Coal is delivered by trucks which empty into manholes at the street level, chuting



COAL AND ASH HANDLING SYSTEM IN BOARD OF TRADE BLDG., CHICAGO

the coal to the storage bunker, from which it is drawn off through undercut gates or Chicago Tunnel Co. (which operate through the Chicago freight subway about 40 ft. below street level) discharge into an auxiliary chute from which the coal is loaded, via a revolving feeder, into the lower run of the conveyor. This elevates and conveys the coal until it is discharged into the storage bunker by means of a movable tripper, along any part of it, thus keeping the storage even.

Coal is drawn from any of nine gates into the Link-Belt, 1500-lb., motor-driven traveling weigh larry, which has a speed of 80-ft. per min., weighs the coal and feeds through a hinged spout into the hoppers in front of the boilers for automatic stoking.

Ash may be handled either by the conveyor or by an 8-in. diameter steam jet ash conveyor. Both systems convey the ash to the storage bin, whence it is discharged into tunnel cars, or taken to street level in buggies for trucking away.

Ash is raked out over the raking chute into the lower run of the carrier or into the steam jet line, conveyed and elevated to the ash storage bin, shown in the upper left-hand corner. From this bin it can be removed as above mentioned.

IN REFRIGERATING SYSTEMS using ammonia, the pressure of the vapor varies from about 20 to 200 lb. per sq. in. while in those using carbon dioxide, the pressures vary from 300 to 1000 lb. per sq. in.

American Gas Association Offers Samuel Insull Award

AMERICAN GAS ASSOCIATION has announced the offering of a special annual award to the member gas company of that organization that has made, during the previous calendar year, the most outstanding progress in distinguished public service. This award has been made possible by Samuel Insull, of Chicago, Illinois, and will be known as the Samuel Insull Award for Distinguished Public Service.

The first Samuel Insull Award will be for the calendar year 1931 and will be presented at the 1932 Annual Convention of the American Gas Association. All member companies of the Association in the United States, its possessions or in Canada, whether large or small, manufactured, natural or mixed gas, will be invited to submit exhibits for consideration of a special committee which will have charge of examining the exhibits and selecting the winning entrant annually.

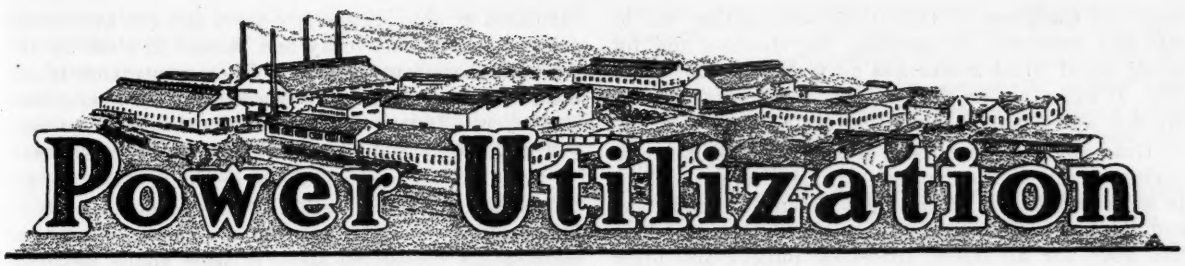
The purpose of the award is to give official recognition of the gas industry to the outstanding accomplishments of its members in rendering distinguished public service, so as to stimulate the industry's efforts in this direction and inform the industry as to the methods by which these accomplishments have been achieved.

In order to make the comparisons of company accomplishments more valid and significant, the following classifications have been established for companies submitting exhibits: Class A—Companies having 125,000 or more meters; Class B—Companies having more than 40,000 and less than 125,000 meters; Class C—Companies having less than 40,000 meters.

The award for the year 1931 will be available to companies in Class A. The award for the year 1932 will be available to companies coming within Class B, and that for 1933 will be available to companies within Class C. In subsequent years the award will be rotated in the same order indicated above.

The winning company will receive an engrossed certificate suitable for mounting in the company's offices as public evidence of its company achievements, and in addition will be entitled to designate three members of its personnel who may attend one of the special courses for business executives such as the course in Public Utility Management and Economics offered during the summer months by the Graduate School of Business Administration, Harvard University, or other courses offered by similar institutions. Those individuals designated by the winning company will be entitled to free tuition and expenses during the period of the course at the institution selected.

THE JOULE-THOMPSON effect, so-called after experiments announced by these men in 1862, is expressed as the difference in temperature before and after throttling. Nearly all gases show a drop in temperature but hydrogen at ordinary temperatures shows a slight rise. A perfect gas would show no change, so that the Joules-Thompson effect is in reality a measure of the imperfection of a gas, an indication of how its behavior deviates from a perfect gas, a more or less hypothetical substance used by physicists to indicate a gas which would exactly conform to the laws of Charles, Boyle and Joule.



Increasing the Life of Conveyors

FREDERICK WEHLE,* ENGINEER WITH 17 YEARS OF EXPERIENCE, WAS ASKED: "WHAT CAN ONE DO TO MAKE CONVEYORS LAST LONGER?" HIS REPLY IS GIVEN BELOW. DOES IT APPEAL TO YOUR GOOD SENSE?

YOUR QUESTION about making conveyors last longer takes me back over the long road I have traveled with these animals and I do think of a few points. In general, the man who has sympathy for machinery has the best luck with it. You know, a man brought up with horses knows a horse's limitations and feels a close kinship to every horse. Does he hitch his friend alone to a two or three-horse load, let him pull a wagon with dry hubs or with brakes dragging and does he underfeed him or neglect his health? Not on your life! I mean the man who actually suffers when the animal does.

Some abuse of conveyors is due to buying them too light, through understating the daily tonnage or neglecting to consider irregularity in feeding. One hundred and fifty tons a day fails to state the case when a conveyor is to receive 30 t. an hour regularly for 5 hr. or where it has a ton of stuff dumped on it whole at 10 or 12-min. intervals. I have seen a 50-t. an hr. coal crusher choked to a standstill by feeding it "carefully (?)" from a one-yard grab bucket. Low upkeep starts with a real study of capacity requirements, present and future, before you buy the conveyor.

Everybody knows that hot, gritty, gummy, wet or corrosive materials are hard on conveyors but, for practically every material that industry has dared the conveyor people to tackle, a right kind of conveyor has gradually evolved. Elevators and conveyors must be built with a full knowledge of the requirements. Before you pull a pair of shoes out of the closet, you know whether you are going to climb mountains, play tennis or walk a tight rope. Before you get prices on a conveyor, be certain that you have made yourself quite clear about the stuff to be conveyed. Suitability is a big step toward durability.

To make conveyors last longer and cost less over a period of years, make up your mind what qualities you are going to buy. Clothes, shoes, wallpaper and trucks are of many grades. Conveyors correspond to trucks, in that fashion plays no part in their price. Greater durability, greater reliability and less upkeep expense are the valuable things paid for when you buy the more expensive materials-handling outfit.

GOOD ENGINEERING LASTS

Seemingly expensive engineering usually means work by better engineers and a good general design based on a real study of requirements. This is important because there is often a question as to whether, for a specific installation, a continuous bucket elevator is better than a skip hoist, or whether the horizontal movement should be by drag or by apron, by belt or by a screw conveyor. Also, whether vertical and horizontal movement may be combined by one of several methods. Wise selection at this point makes a great difference.

Good engineering of the general layout will go farther. It insures rigid and dependable supports to

*Engineer, Link-Belt Co., Chicago, Ill.

FIG. 1. OVERLAPPING BUCKET CONVEYOR IS WELL ADAPTED TO COAL HANDLING

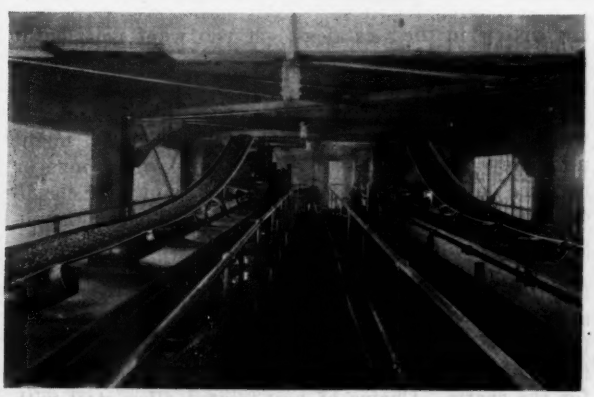


FIG. 2. TROUGHING ROLLERS WITH ROLLER BEARINGS CUT DOWN BELT CONVEYOR POWER

carry the machinery so that it will stay in line, will be safe and accessible for painting, for cleaning and for oiling, all of which means less ultimate cost and longer life. It means chutes that will not clog, clearances that are safe and paths of travel that are economical.

Good engineering extends to every detail of a conveying system, and is the least expensive thing you buy. It includes selection of the right design, the right size and the right material for every shaft, bearing, chain and gear, for all idlers, sprockets, pulleys and other parts; all for safety, dependability, long life and lowest power consumption. The best engineering means the most service for the least money.

Even the leading engineers and conveyor builders manufacture and can furnish several grades of almost

FIG. 3. FOR MANY LOCATIONS THE SKIP-HOIST PLANT IS THE LONGEST LIVED AND MOST ECONOMICAL EQUIPMENT

any article in their catalogs. If you want your outfit unusually durable and to require the minimum of attention, let your engineer know it. He will realize that he is dealing with a man who appreciates quality and you will be offered a grade of machinery which you might never have known existed. Do not give your conveyor man the impression that you are going to buy the cheapest thing the conscience of his concern will let him submit in a competition for low first cost.

Roller-bearing belt conveyor idlers of today require less than half the power of old kinds, last much longer and need be lubricated only twice a year. Sets of cut-tooth alloy-steel gears operate silently in oil in compact heavy dustproof housings, with dustproof roller bearings for the shafts. Chains of heat-treated alloy steel with case-hardened pins and bushings could not have been furnished at any price a few years ago but are turned out in quantity lots today and carried in stock by the foremost chain manufacturers. These improvements and many more were the result of a demand by discriminating buyers. If you want the results that they demand, you will just have to be a discriminating buyer yourself.

For duplicate conveyors used in identical service, the difference in life will naturally depend on the care in maintenance. This is important to watch, because the maintenance considered strict in some plants would be sniffed at by foremen in other plants.

Making conveyors last longer is largely up to the man responsible for their selection. Perhaps the day will come when the buyer will explain his needs and then ask: "Who can give me the best quality work for the $4800 I have in my budget for this conveyor and how much better could you build it for $6000?" To my mind that would be the way to get comparable proposals, and so start some real competition in the direction of quality and durability.

Circulation in Cold Storage Rooms

Good air circulation is necessary in cold storage rooms to avoid deterioration of stored products. Where circulation is poor, natural circulation can sometimes be improved by baffling; in other cases, forced circulation

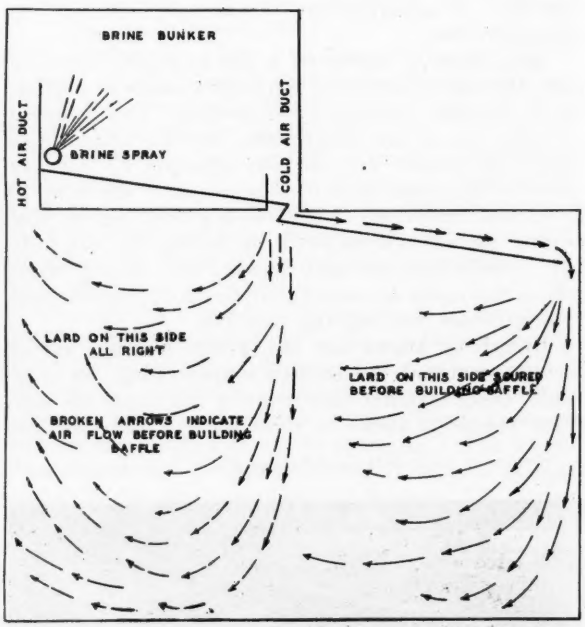

BRINE BUNKER
HOT AIR DUCT
COLD AIR DUCT
BRINE SPRAY
LARD ON THIS SIDE ALL RIGHT
LARD ON THIS SIDE SOURED BEFORE BUILDING BAFFLE
BROKEN ARROWS INDICATE AIR FLOW BEFORE BUILDING BAFFLE

FIG. 1. CIRCULATION WAS IMPROVED BY A COLD-AIR BAFFLE

is a necessity. By some means, temperature must be maintained uniform in all parts of the room to avoid condensation, mold and decay.

In one room, where lard was stored, which must be chilled rapidly to prevent souring, the side under the bunker worked perfectly, while in the one away from the bunker, lard always soured. Testing air currents showed that the air from the cold air duct, Fig. 1, was short-circuiting to the hot duct side, leaving the right-hand side of the room uncooled. By putting in a baffle,

the circulation was forced to all parts of the room and the trouble overcome at a cost of only $75.

In another room, used as a sharp freezer, the side wall coils were 12 pipes high and center coils 10 pipes high by 4 wide. Arrangement was as shown in the plan view, Fig. 2, the total pipe being one running foot of 2-in. pipe per 4 cu. ft. of space.

In hot weather it was difficult to keep temperature uniform, and tests showed temperatures at the ceiling near side walls of 22, 27 and 28, while floor temperatures were 15, 10 and 15 respectively. The warm air leaking through roof and walls was lying stagnant along the ceiling, which was of concrete lined with 6 in. of cork.

Two fans, a 24-in. and a 16-in., were installed near the ceiling, pointing across the room in direct line with the refrigerating coils. By trying different locations we soon found those which gave best results and temperatures became for ceiling, 14, 10 and 13 deg. and for

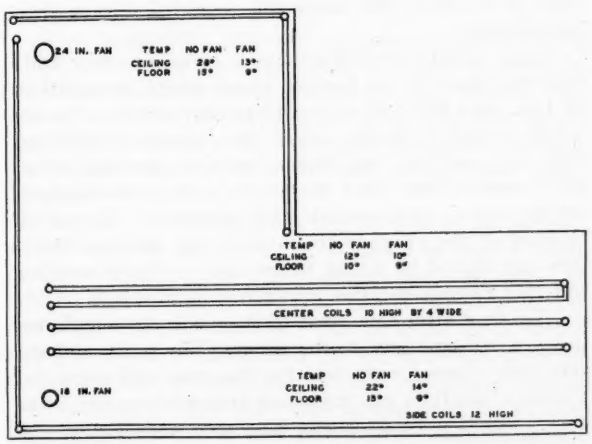


FIG. 2. FAN CIRCULATION CURED A DEAD LAYER OF WARM AIR AT THE CEILING

floor 9, 9 and 9 degrees respectively. Meat was quickly chilled in all parts of the room and kept cool, which stopped sweating, gave it better color and increased its sales value. Sweating during or after chilling produces what packers term a "milk streak" of lighter color. This does not materially affect taste or food value but lessens market value. The slight cost of installing and operating the fans was repaid many times by increased value of the meat.

Kansas City, Kans. J. F. STALEY.

Motor Winding Trouble Located

IN ONE CASE, direct-current motor trouble was almost corrected without locating the cause. On a 10-hp., compound-wound, interpole motor driving a pressure oil pump, the commutator would get rough while that on a duplicate motor did not. Also the commutator would get hot and pressure drop in the oil system.

One repair man made a few tests, then moved the brushes and brush arm off the marked neutral position, without rechecking the commutator's operation. This procedure apparently remedied the situation as far as the repair man was concerned. The sparking diminished at the commutator, the speed of the motor increased and no more complaint was made regarding the oil pressure. It was not long, however, until complaint was made by the operators that the brushes were not lasting long, the slots in the commutator seemed hard to keep clean, the commutator would not take a polish and it had to be cleaned frequently or the sparking would become serious.

After the unit had been completely overhauled about one year previously, and was put back in service, it did not operate properly. When a piece of lamp cord was fanned out and held against the commutator end while running, no sparking position showed at a point beyond the brushes. It was evident that the circuit was not correct. As shifting the brushes changed the speed, it was suspected that the field circuit was involved. It was assumed that the interpole winding was correct or the commutator would spark badly. When the shunt field was checked with an ammeter in the circuit, the amperage indicated full field and field coils heated evenly. By deduction, the series field was left as the offender.

The simplest thing was to reverse the terminals of the series winding. This was done, the brush yoke was set on the factory neutral mark and the motor started up. The speed checked correct and commutation was good. Operation since that time has proved that the diagnosis was correct.

This lamp cord test is the simplest way to check for the neutral brush position. Hold the spread end on a piece of flexible lamp cord against the end of the commutator at the brush position while the machine is running. If no sparking is obtained at the end of the wires, it is an indication that the brushes are on the neutral position. It will be advisable to move the cord around the commutator a short distance either side of the brush position to see whether a light sparking is obtained. Absence of sparking on one side of the brush position would indicate that the brushes were off the neutral position. Before making this test, the free end of the wire should be carefully insulated so that there will be no danger of causing a short-circuit or ground.

Hobart, Ind. HARRY J. ACHEE.

Warm Air for Ice Cans

REFERRING to the article under this same head by J. F. Staley in the August 15 number of Power Plant Engineering, page 948, a concern for which I have done considerable work has been advocating hot air lines and air headers for raw water agitation for about four or five years. The reason for this is that, especially during the winter months, the cold air taken from the atmosphere and passed on to the blower and then to the tank soon becomes chilled and the moisture condenses. This stops the air from passing on to the cans in the proper proportion that is prearranged for each ice can. In order to eliminate this stoppage in the various fittings on the tank, the proper method is to warm the air in the air headers, which is the nearest point that you can get at to heat it, so that the air will be of temperature far from the dew point.

This may sound odd to many engineers but it is practical. In fact it is the only practical method of handling air agitation equipment in the northern states.

Newark, N. J. W. F. SCHAPHORST.

Drinking Water System Experiences

By G. H. Kimball

SOME YEARS AGO, the writer took charge of a plant, which had, a year previous, installed a centrally controlled system for supplying cooled and filtered water to all parts of the factory for drinking purposes. The area covered consisted of an L-shaped building of four stories and basement with a branch run to a wooden restaurant building.

The main line was made up of 1¼-in. pipe heavily insulated with 21 bubblers connected. Originally the system had about 800 ft. of pipe in the circuit. At the top of two risers, 20-gal. tanks were placed for expansion or as surge tanks, although for just what purpose was never ascertained.

For the cooling machine, all of the refrigerating mechanism is enclosed in a sealed spherical vessel which revolves in an open tank known as the condensing tank. This is equipped with a float valve which controls the supply of cooling water. Connected to this first sphere by a hollow shaft is a cylindrical vessel which allows for the expansion of the refrigerant and which is revolved in an insulated tank called the cooling tank. At a higher level is an insulated tank of 100 gal. capacity which is kept full by a float valve from the city supply.

In the original installation, the city water ran through two filters before running to the storage tank. The water flows from the storage tank to the cooling tank and is controlled by another float valve which maintains the proper level.

Circulating is by a triplex, single acting pump, with 2½ by 4-in. plungers running 75 r.p.m., driven by belt from a 2-hp. motor.

Action of the system is as follows: The pump draws the cooled water from the cooling tank and discharges it into the circuit. After the lines are filled, water that has not been used at the bubblers returns to the cooling tank where there is a pressure-retaining valve that acts like a relief valve and maintains a pressure up to 125 lb. per square inch on the system. Since more or less of the water does not return, the difference is made up by the float valve in the cooling tank.

We find that there is about 3 deg. rise in the temperature of the water as it returns to the tank to mingle with the cooled water. The thermostat is set to stop the cooling machine when water is at 55 deg. and to start again when it has reached 60 deg.

This system operated for about 5 yr. before any additions were made to it. One of the first difficulties was in the surge tanks which began to leak. These were removed with no change in the operation of the system.

In summer, considerable difficulty was experienced with the condensing tank. At one time it seemed as if the machine had broken down inside since it was working with difficulty and on one of the hottest days in summer it had to be stopped. The temperature of the water rose to 70 deg. and it was decided to try helping out the machine by putting ice into the cooling tank. The use of 200 lb. lowered the temperature to 60 deg. when the machine was started and has given no trouble since, even with heavier demands thrown upon it.

To guard against damage of the machine by insufficient condensing water, a small float was placed in the condenser tank which will cut off the current if the level falls low enough by dropping a bar across two contacts which are connected to the controller.

On heavy drops in pressure the relief valve at the end of the return failed to close and one of greater range was tried but did not work satisfactorily. The spring was then removed and a lever with a weight on it substituted which remedied the difficulty.

With a spring relief valve as the pressure causes the disc to rise there must be considerable range when handling a liquid and the higher it rises the more compression on the spring. If the tension is adjusted to allow enough rise, when there is a drop in pressure the spring may have too little travel to close the valve tight. With a weighted disc it requires no more pressure to push the valve wide open than just to crack it, hence a large flow is relieved without too great rise in pressure while a quick demand on the system with the resulting drop in pressure will allow the weighted disc to close immediately.

After about 5 yr. of service, a large six-story addition was made to the factory which added some 600 ft. of 1-in. pipe laid out in two loops and connected to the branch which formerly served the restaurant building. This new addition had eleven bubblers attached which had larger orifices than the others so that the demands on the system were considerably increased. It was the opinion of the people who installed the machine that a new one should be added to help out in warm weather, but this recommendation was never carried out.

Not long after this, some of the employes complained about a strange taste to the water. The tanks and system were cleaned with soda but the taste still prevailed. Chemical analysis was made and traces of vegetable bacteria, which were harmless, however, were found and, since the city water was known to be of excellent quality, removal of the filters was recommended, since they might aid the collection of vegetable matter. It was recommended that the system be treated to a chloride of lime solution. After this was done the taste gradually disappeared.

Another difficulty that arose was the presence of air in the system. At first it was customary to close down the pump nights and Sundays. Gradually, the bubblers being opened by the watchmen and others, the water would be drained from the upper sections of the system.

As a consequence, when the pump was again started the air rose to the highest point and, when a bubbler was opened, the mixture of air and water would be discharged to the ceiling, if the person desiring a drink did not get in the way. This air would also stir up any rust in the pipes so that the water would be cloudy for some hours.

Keeping the system always full of water was then tried by connecting to the city supply through a swing check valve, which would automatically open when the pressure dropped low enough. This solved the air problem but made it hard to prevent some leakage of city water when the pump was stopped.

In any system where the bubbler is taken from the horizontal lines, the connection should always be made from the bottom of the pipe since a small quantity of air will travel along the top and, at the high point of

the system, will collect so that a bubbler taking from the top will discharge it continually.

Recently an article in Power Plant Engineering recommended a water temperature of 45 deg. at the tank. We have never tried to get a lower temperature than 50 deg. and much of the time the thermostat is adjusted to stop the motor driving the cooling machine when the temperature of 55 deg. is reached, the motor starting again when the temperature has risen to 60 deg.

It would seem that these temperatures are well suited to days when the room temperature is 80 deg. or over, when the demand on our system is such that the machine has to run continuously to hold the temperature at 60 deg. so we could not lower it if we wished. We have received no complaints about the water being too warm.

We think that, in a system of this sort, a centrifugal pump would be better suited to the work than a reciprocating machine. It would have to be two-stage but it would deliver a steady stream and have to be packed only around the shaft. All valve troubles would be eliminated.

It is a question whether independent refrigerating units will not in the future take the place of centrally operating drinking water systems in many plants. We have 30 bubblers and 30 units which, at $250 each, would cost $7500. If each has one-eighth horsepower motor, the power consumed by all of them at one time would be about 4 hp.

Expense of installing our central system was around $12,000 and it has 5 hp. in motors. It uses a large amount of city water for cooling purposes, some of which can be used as boiler feedwater in cold weather but very little in summer. So, separate units would consume no more power and the expense of connecting the city water to each unit should not exceed $1500, leaving a substantial difference in cost over the central cooling system. Also the maintenance charges should be much less.

Babbit Putty

In regard to babbit putty mentioned in my article on Socketing of Wire Rope in the Sept. 1 issue, about which inquiries have been received; while several firms make a product for such use and I presume as good as that which I am using, I have found Babbitrite, which comes in 25-lb. steel pails, satisfactory for all kinds of babbit work.

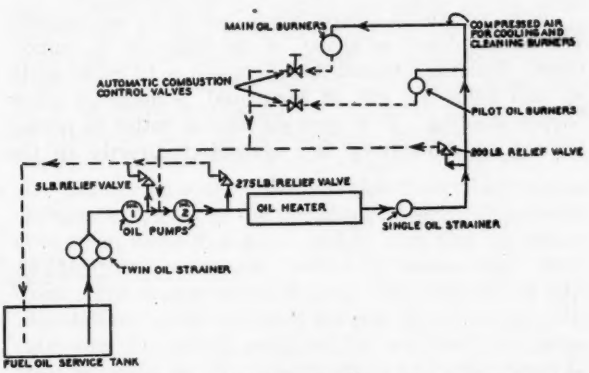
Cold Spring, Minn. Chas. A. Peterson.

As a pump an injector is inefficient, but for boiler feed service has the advantage of conserving and returning to the boiler practically 100 per cent of the heat supplied to it. From a purely economical standpoint, however, it is inferior to a boiler feed pump arrangement where the exhaust steam is used in a feedwater heater. The remarkable simplicity, small size and low cost of the injector makes it of value for standby service; in locations where economy is not important or operation intermittent; or for handling corrosive materials where ordinary pumps would not standup. The energy efficiency is higher when the motive fluid is relatively heavy, or dense in comparison with the material to be handled, as for instance, a water ejector to evacuate an air chamber.

Fuel Oil for Standby Plant

For plants which require heating service yet need standby provision for power or process steam, fuel oil offers advantages in flexibility and economy, since banking losses can be eliminated and response to increased demand is prompt. Such a plant installed in San Francisco for the Great Western Power Co. was designed by McClellan & Junkersfeld, Inc. and details developed by H. G. Thielscher, mechanical engineer. It is described by Harold K. Fox, construction engineer, in a recent issue of Heating, Piping and Air Conditioning.

This plant is used as a standby for current from the hydroelectric stations, in case of interruption or sudden peaks. On standby, it produces 20,000 lb. of steam an hour from two 450-hp. boilers but may be required to deliver 600,000 lb. on instantaneous demand. Mechanical atomizing burners are used, 9 pilot burners and 20 main burners to each boiler, an individual connection



OIL FUEL SYSTEM ARRANGEMENT FOR HEATING AND EMERGENCY POWER

being run to each burner from the supply mains. Steam is supplied at 400 lb. to a 43,750-kv-a. turbine-generator set, which floats on the system.

Arrangement of the fuel system is shown in the illustration. Pump No. 1 draws oil from the service tank through a twin strainer and delivers it at 5 lb. to No. 2, oil not needed being bypassed back to the tank. Pump No. 2 delivers at 200 lb. to supply headers through an oil heater, excess not used being returned through a 200-lb. relief valve to its own suction. If pressure rises to 275 lb., oil will be bypassed to the service tank but, under ordinary conditions, the heated oil is kept circulating in the 200-lb. system. Heating is by live steam, temperature being controlled by thermostats.

Supply of oil to the burners is regulated by automatic control valves, actuated by steam pressure, only the pilot burners being used for standby operation. When load comes on, the main burners are opened and lighted from the pilot burners.

If the plant runs for any considerable time at full load, pumps Nos. 1 and 2 can be cut over to run in parallel, each drawing from the service tank but series operation for standby and light loads avoids return of heated oil to the tank.

Analysis of accident records shows an increase in number of infected wounds. This increase in cases of infection or blood poison indicates that some employes have neglected the prompt treatment of small wounds.

Injector Serves as Boiler Compound Feeder

FEEDING BOILER COMPOUND to boilers by an injector was accomplished as shown in the diagram of connections. Boiler compound tank C, which is 12 by 12 by 12 in. and holds 6½ gal. of compound, is made of heavy copper sheeting. It is open on the top better to permit mixing and dissolving the compound directly in the tank. It is not necessary, as before, to dissolve the compound in a pail.

Formerly I had trouble feeding the boiler with a closed compound feeder fitted with a funnel on top because some of the compound is hard to dissolve and continually clogged up the passage. Because it is hard to get hot water by the use of a boiler feed pump, I connected the injector, I, to the compound feeder tank.

To dissolve the compound, I pour it in the open tank and mix it with hot water which I obtain by means of the injector by opening valves 3, 6 and 8 and closing valves 4, 5 and 7, thus creating a bypass from the boiler feed line. Before I start the injector, I prime it by opening valves 7 and 8, closing valve 7 after priming is complete. Valves 8 on the feedwater tank line and 9 on the steam line are then opened and the injector started. Tank C is filled with water which has been heated almost to boiling point, after which valve 6 is closed and valve 5 opened. After the compound is dissolved, valve 10 is opened, valve 1 closed and the compound from tank C fed to the boiler by means of the injector.

When the injector does not function, the pump is used, in which case valves 1, 10 and 14 are opened and valve 3 is closed. After sufficient compound is fed to the boiler, valve 1 is closed. The compound tank must be 6 in. higher than the injector in order to feed the compound to the boiler by use of the injector. All pipe fittings and pipes are 1 in. in size and only brass gate valves are used.

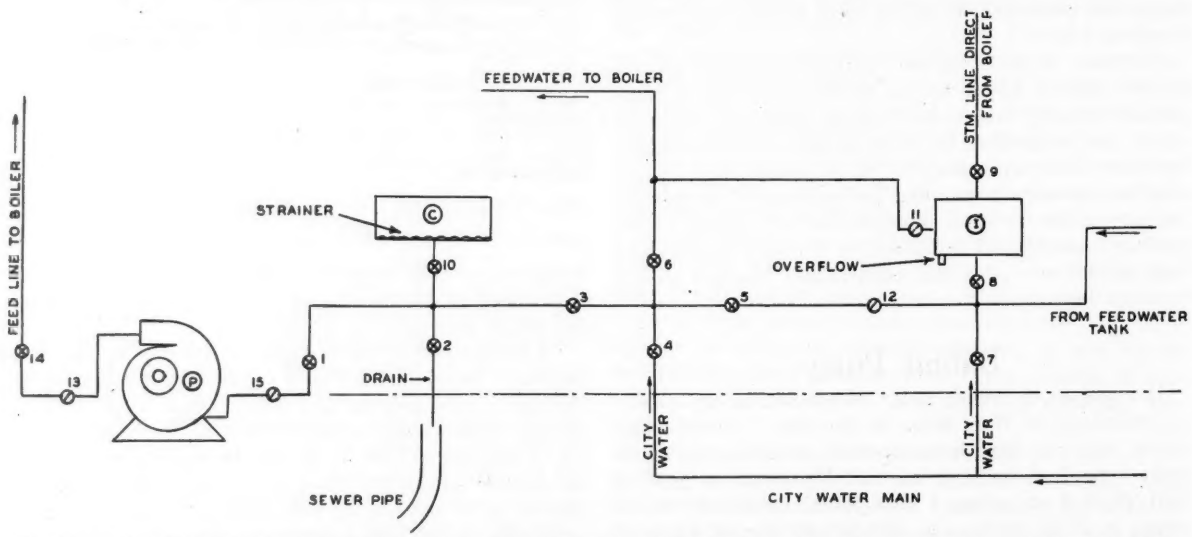


DIAGRAM OF CONNECTIONS SHOWING HOW FEED PUMPP OR INJECTOR I MAY BE USED TO FEED BOILER COMPOUND FROM THE MIXING TANK C TO THE BOILER

Sometimes the compound feed line becomes clogged, in which case I close valve 10 and open valves 3 and 5, also open valve 2 which connects to the sewer. After thus draining the line, close valves 1, 5, 6 and 10 and open valves 2, 3 and 4 to flush out the line. With the connections shown, you can bypass any way you wish. Since I have been dissolving the compound in an open tank, I have had no more trouble and I have found it handy to feed the boiler compound with the injector.

Seymour, Conn. CHARLES MEHR.

Selecting Stokers for New England Fuel

On page 1010 of the September 1 issue, J. R. Darnell discusses an article by R. A. Foresman and the writer, which appeared on page 620 of the June 1 issue. Mr. Darnell takes exception to certain statements in the article, and supports his exceptions by quoting certain published discussions. The article was part of a paper presented before the New England Division of the A.S.M.E. and published in sections with arbitrarily inserted headings and sub-headings.

In this particular section, the heading "Preheated Air Does Not Increase Capacity or Efficiency" was inserted. Taken alone, this heading is rather startling because it is obviously fallacious and to some extent warps the meaning of the subject matter. The authors stated that preheated air does not measurably increase the efficiency of combustion. They gave due credit to the use of preheated air as a means of heat recovery, and consequently a means of increasing the overall efficiency of the steam generating unit. One must differentiate between the effect on one element, i.e., the stoker, and the effect on the complete generating unit.

It would seem that Mr. Darnell does not have a correct impression of the intent of the original paper, which was to present certain practical information and ideas concerning the use of underfeed stokers in New England. The paper was not a technical discussion of minute detailed figures; it was intended to be a summation of commercial practice.

It is easy to find occasional data which will contradict such a paper. Consequently, extended discussion of figures is fruitless unless all the data from every plant in the country can be gathered for comparison. We do not intend to enter into a prolonged discussion of pros and cons, but will endeavor to show justification for the general statements which were made.

Preheated Air

Underfeed stokers under average conditions, using cold air, operate with a combustion efficiency of 98 to 99.5 per cent (based on losses to the ashpit, in unburned gases, and unburned solid carbon passing up the stack), and with from 10 to 25 per cent excess air. When this is considered, it will be appreciated that preheated air can effect but little worthwhile improvement even if it should produce absolutely perfect combustion. Since even theoretically possible gains are so small, it is hardly worthwhile to discuss the use of preheated air as a commercial investment for improving combustion.

The authors' statements regarding preheated air were of an entirely disinterested character. Our company builds stokers for use with either cold air or preheated air and in either case expects substantially equal combustion performance and commercial results from the stoker itself.

Our statement was that preheated air does not increase the capacity or efficiency of combustion. We further stated that the value of preheated air lies in the amount of heat recovered and returned to the boiler. This gives due credit to the preheater for the function which it performs, i.e., the recovery of waste heat. If the recovered heat increases the effectiveness of heat absorption by the boiler, this still does not invalidate the statement that preheated air does not increase the efficiency of combustion. One must differentiate between the effect on combustion and the effect on heat absorption. Incidentally, I may remark that inspection of the data from a number of tests with both cold air and preheated air shows very little justification for the statement that preheated air reduces the temperature of the gases leaving the boiler. There are so many other variables in boiler testing, such as unavoidable errors in the data, difference in fuel characteristics, difference in furnace design, difference in the percentage of excess air and so on, that it is virtually impossible to be sure of absolute accuracy in such comparisons. Usually the "probable error" in the data exceeds the indicated difference in performance.

Mr. Darnell quotes "Boiler Test Results with Preheated Air" by C. W. E. Clarke. These tests were conducted in 1923 and were among the first ever conducted on underfeed stoker equipment using preheated air. Knowledge of the art of operating stokers with either cold air or preheated air at the time these tests were run was certainly not equal to present day knowledge. While it is true that the data from these tests show improved combustion performance due to the use of preheated air, the performance obtained with preheated air was inferior to that obtained today with cold air. Again considering the fact that modern equipment operates so closely to the maximum theoretical performance when using cold air, it will be seen that the results of these tests cannot be applied to present day conditions. The data obtained from a large number of later installations, using both cold air and preheated air, indicates that the effects produced by preheated air in the tests reported by Mr. Clarke were more the result of circumstances than a definite, fundamental, physical change.

Some writers have attributed a lower unburned gas loss to the use of preheated air. Such losses are customarily lumped in the "radiation and unaccounted for" losses. The test results reported by Mr. Clarke show a higher radiation and unaccounted for loss with preheated air. Here is another example of the contradictions which occur in comparing small incremental differences in performance.

Mr. Darnell quotes a statement of an operating company using chain grates showing the benefits obtained by the use of preheated air. The authors' article, as well as the statements which are here being made, is concerned only with underfeed stokers.

Mr. Darnell quotes statements of J. G. Worker in a discussion of the use of preheated air. A chart is shown giving curves of efficiency with preheated air and with cold air, also showing the air temperature. The writer has broken these curves down into the following table, which is self-explanatory.

Rating	Efficiency Preheated Air	Efficiency Cold Air	Air Temp. °F.	CO_2 as Stated	Increase Efficiency % Eff.	Heat Returned by Air %	Apparent Gain Due to Improved Combustion
250	90	82	390	12.5	8.0	8.6	—0.6
350	88	80	430	16.5	8.0	7.3	+0.7
500	85	75	500	16.5	10.0	8.7	+1.3

It should be remembered that the use of preheated air decreases the rate of combustion by the amount of heat recovered. At the maximum capacity, this decrease in rate of combustion reduces the losses in un-

burned fuel. Therefore, at maximum capacity, a gain in efficiency in excess of the amount of heat recovered is shown. This, however, is not a chemical or physical effect of preheated air on the combustion process. Any other system of heat recovery, e.g., a larger economizer, would produce the same result.

It is recognized that the impression of many engineers is that preheated air improves combustion. It is possible that this impression is due to the fact that these engineers looked for improvement from this source when preheated air was first introduced. Wherever tests indicated an improvement, these tests were reported.

We have known of a few cases where the combustion performance was actually worse when preheated air was used. We know of many cases where no measurable difference was shown. Such cases have seldom or never been written up for publication, consequently the general impression that improvement in combustion can be effected still persists in spite of the fact that there is so little room for improvement.

I think that the best answer to the question from a commercial viewpoint lies in the fact that many of the large, ultra-modern stations recently built or now in the process of building are not using preheated air simply because the heat balance of the station does not call for it. I wish to emphasize that this discussion is by no means an argument against the use of preheated air. Preheated air should be used wherever the heat balance of the station and the economics of the installation justify it; however, it should be used on its merits as a heat recovery system and not because of an infinitesimal gain in combustion performance.

Mid-Western vs. Eastern Semi-Bituminous Coal

Mr. Darnell also questions our statements concerning the capacity of stokers with various fuels. The authors described the fundamental reasons why the measurement of combustion rate in pounds of coal per square foot is misleading. It was shown that the velocity of air through the fuel bed is the fundamental factor limiting the capacity. If all other limitations are removed, it is obvious that the ability to retain the fuel on the grate surface is the ultimate limitation of capacity. Since the amount of air required per pound of fuel is a function of the combustible contest of the fuel, i.e., the heat value of the fuel, the air velocity is a function of the amount of heat released per unit of area and time rather than the amount of coal consumed per unit of area and time. Applying this reasoning, it is shown that it is possible to burn a greater weight of coal per unit of grate area as the heat content of the coal decreases.

It is well known that the coals found in the Middle West ignite more readily and burn more freely than Eastern semi-bituminous coal. In the past, the principal limitation in the burning of Midwestern coal was the ability to dispose of the large amount of ash in the coal so that clinker formations would not interfere with the operation of the stoker or with the combustion process. If the ash can be so handled that it does not interfere with combustion, it would certainly seem that the coal which is more readily ignited and which burns more freely will give a higher capacity.

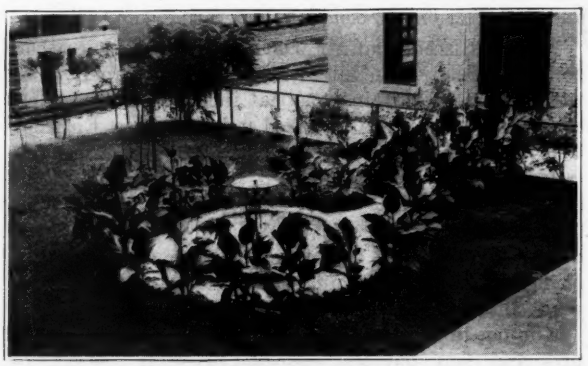
We consider that the limitation of air velocity is a fundamental, ultimate and inescapable one. We further consider that the limitations created by clinker formation are secondary and not fundamental. The present level of engineering development is such that stokers can be built to handle and dispose of ash and clinker effectively so that combustion can proceed without interference from this source. Modern furnaces with underfeed stokers are not limited in capacity by clinker formation.

Tests conducted on Westinghouse stokers with clinker grinders over the past several years show substantially the same steam generating capacity per unit of grate area with all coals mined east of the Mississippi River. The differences in capacity obtainable with different coals are generally smaller in amount than the error which occurs in all determinations of ultimate capacity.

E. Pittsburgh, Pa. Donald J. Mosshart,
Westinghouse Elec. & Mfg. Co.

From Cinder Patch to Eden

Improvement in plant surroundings that can be accomplished with the expenditure of a little effort, time and planning is illustrated in the accompanying figure.



BIRDS, GRASS AND FLOWERS SUPPLANT CINDER DUMP AT POWER PLANT

What was once a square of unsightly cinders was transformed into an attractive entrance to a power station. A few old brick, some willing grass and the rough and eager canna comprise the formula. It will work almost anywhere.

Missouri Valley, Ia. Frank W. Bentley, Jr.

Condenser Tube Leakage

In the Sept. 15 issue an article on Condenser Maintenance makes reference to condenser tube leakage, the prevention of which was regarded as one of the most important operating requirements of the condenser in the high-pressure station of today.

The contributing causes, it is pointed out, are "poorly packed," holey and split, or corroded tubes. "Poorly packed" tubes are no doubt a cause but why they are poorly packed is not generally recognized.

I have often wondered why condenser manufacturers persisted in threading condenser tube sheets practically the full depth of the tube sheet. Most of this threading is of no practical value; rather it is a serious hindrance in packing condenser tubes especially with corset lacing or other similar packing. The difficulty of getting the packing tight over a threaded surface of this kind must be apparent. The undue pressure necessary to force

this packing home must likewise be apparent and the filling of the interstices that unnecessarily exist to prevent leakage is quite evident. Just how this packing is thus mutilated and cut into shreds may be gleaned on its removal. It seems to me that this condition could hardly be made worse.

For an improved condenser tube sheet that would greatly minimize the trouble now usually met, my idea would be to eliminate all this unnecessary threading, that is, all but two or three threads at the entrance of the stuffing-box required to hold the ferrule sufficiently firmly in place and leave the balance of the stuffing-box wall smooth as is done in any other stuffing-box for the free movement of the packing. The pressure necessary to make the tube end tight may thus be lessened, avoiding necking or crimping of the tube which is a common source of leakage, and facilitate addition and removal of packing which, after once in place, is rather difficult to pick out of small sized stuffing-boxes.

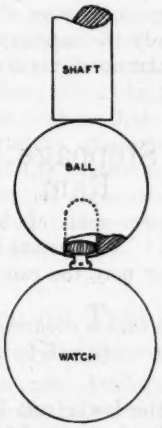
We had quite a few tubes damaged by long screw threads that broke through where they were necked by the packing before they were in service very long.

Corrosion might also be reduced and the use of special or extended ferrules and wearing tips made less necessary, if the tube ends were not made so hard to withstand the excessive pressure that is now put on them by the present type stuffing-box.

St. Helens, Oregon. CHAS. LIEBAU.

A Five-Cent Revolution Counter

NEARLY EVERY home or workshop has one or more discarded dollar watches. So long as the hand setting mechanism in such a watch is workable and the hour hand is in place, it can be used as a speed indicator.



RUBBER BALL FORMS SIMPLE CONNECTOR FOR USE ON WATCH FOR SPEED INDICATOR

Take a solid rubber ball of about 2 in. diameter, which can be bought for five cents and cut a hole in one side just large enough in diameter to make a tight fit over the crown of the watch. To use this device, it is first necessary to determine the comparative rate at which the hour hand moves. This is done by pressing the ball end against a shaft so as to cause the hand turning gears to mesh, then turning the ball to note how many turns of the ball is required to cause the hour hand to make one revolution.

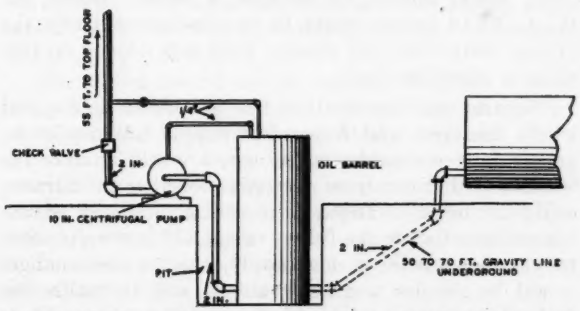
Suppose this to be seven turns. Press the ball against the end of rotating shaft whose revolutions are to be counted, using enough pressure to make the gears mesh and count the number of rotations the hour hand makes in one minute. Now multiply this number by 7. The result will be the number of revolutions per minute.

It is obvious that any watch could be used for the purpose described but it is better to use a discarded watch as there is a possibility of doing harm to it at high speeds.

Lakeview, Ont., Can. EDWARD JAMES.

Overcoming Centrifugal Pump Troubles

AT OUR PLANT there were installed various churns from which buttermilk was to be pumped or drained by gravity to a 10-in. centrifugal pump installed in a pit 4 ft. deep, which was from 50 to 75 ft. from the churns,



CHANGE IN PUMP LOCATION AND IN PIPING CONNECTIONS OVERCOMES AIR BINDING OF CENTRIFUGAL PUMP

and delivered 55 ft. to the top floor, discharge and suction being of 2-in. pipe.

I was confronted with the following trouble, the pump becoming bound not only by air but by foam from the milk, due to churning of the pump. As the suction was great, it would pull air into the line continually from openings at floor level between the churn inlet and lines. The pump was operated at intervals of 15 min. by switch control at the churns. It kept the operator going to the pump and opening air pet cock, which was considerable lost time. After the first lot of milk was pumped, the weight of milk on the check valve would be so great that the pump could not lift the load and start pumping. Air pulled in at the packing glands. At times the pit would become flooded with water covering the pump and motor, causing insulation of the motor to break down.

The sketch shows how all this trouble was eliminated, by placing pump and motor out of the pit with two ¼-in. lines installed as shown, discharging at all times back into the barrel placed in the pit high enough not to overflow in case the fuse on the motor line should blow. When the pump becomes air bound the barrel will fill to the top of the pump lifting the air to the top of the pump and discharging with some milk to the barrel. After pump is shut down, discharge line above check valve drains back to the barrel relieving the load on the pump when starting next time. The pump will not fail to work when the packing gland leaks badly.

Salina, Kan. F. M. MYERS.

Furnace Construction for Natural Gas

WITH REFERENCE to H. A. M.'s question on page 1074 of the September 15 issue, regarding furnace changes necessary to permit burning gas in a hand-fired coal setting, is not the use of checker work questionable? I have burned natural gas in various types of furnaces and my experience has been that the entire absence of furnace obstruction has given greater efficiency.

It would appear to me that a better method for H. A. M. to follow would be to eliminate entirely the grates, bridge wall and checker work and depend on fuel oil as a substitute fuel.

Natural gas distribution has advanced to a point where shortages and failures of supply are negligible, and if I were considering its use, I would analyze the conditions thoroughly to determine whether the furnace could not be so arranged as to utilize the many advantages of gas fuel to the fullest extent. If it were possible to put dependence in his supply, the furnace changes would be simpler and he would be able to realize the full efficiency of his fuel. I do not believe he could do this with the arrangement shown.

Fuel oil as a standby fuel is ideal for a gas-fired furnace since no ignition arch is necessary and volume requirements are very similar. The burner for natural gas need not be elaborate; home-made arrangements of pipe and fittings are giving good results in many plants. For the ordinary coal-fired setting, which is probably too low, a short flame burner would be desirable in order to prevent flame impingement on the tubes. H. A. M. will find natural gas to be an ideal fuel from the standpoint of efficiency, flexibility and cleanliness.

Tulsa, Okla. JOHN S. BLAIR.

Centrifugal Pump Arrangements

WE HAVE TWO double-suction, volute-type centrifugal pumps each having a capacity of 2100 g.p.m. at 1800 r.p.m. against a 386-ft. head. These pumps are direct connected to 325-hp., 3-phase, 60-cycle, synchronous motors operating at 440 v.

These pumps are connected in series, taking water from a well 12 ft. below pump level and discharging 3,000,000 gal. per 24 hr. against 170 lb. pressure. They are also connected to run in parallel delivering 6,000,000 gal. against 85 lb. pressure. It is desired to supply water at 60 lb. pressure to the suction side of the pump and deliver it at 85 lb. pressure.

1. Is this practicable?

2. How many gallons will be delivered per 24 hr. under the new conditions in which the size of suction and discharge pipes to the pumps will be 10 in., the size of impellers, 15 in. diameter and 2 in. wide, the revolutions per minute will be 1800, voltage 440, amperage 340 and the driver, a 325-hp. synchronous motor?

W. T.

A. Connected in series, the discharge stated is 3,000,000 gal. per 24 hr. which is 2083 g.p.m. against 170 lb. pressure. In parallel, the discharge is 6,000,000 gal. per 24 hr. which is 4166 g.p.m. against a pressure of 85 lb. If the suction pressure is to be 60 lb. as stated, the parallel arrangement alone should be considered.

On this basis, it will be possible to provide pumps with new impellers, enabling each pump to deliver a maximum of 2600 g.p.m. at 1800 r.p.m. against a discharge pressure of 85 lb. when supplied with 60 lb. suction pressure. The pumps can then pump against a total head of 25 lb. per sq. in. and the two pumps in parallel will give 5200 g.p.m. or 7,500,000 gal. per 24 hr. against a pressure of 85 lb. Each pump will require 52 hp. to drive it.

If the pumps were connected for series operation, using the same propellers and operating under 60 lb. suction pressure, they would deliver a total of 2600 g.p.m. or 3,750,000 gal. each 24 hr. against a total pressure of 110 lb. at 1800 r.p.m., the power required to drive the pumps being the same.

In considering a problem of this kind, it is always best to consult the manufacturer of the pumps in question to obtain not only the capacity and power requirements of different arrangements but also the necessary costs.

Coal Supply Stoppage Heats Stoker Ram

WHAT CAUSES lower rams of double-ram underfeed type stokers to heat? What remedy can be applied to prevent this and how may the ram be cooled best after overheating?

This is a problem that is occurring daily at our plant. Any suggestions of remedy will be gladly received.

E. M.

A. Heating of the lower ram is almost always due to a stoppage in the fuel supply to the retort. This stoppage may be caused by wet coal or by some foreign object which prevents the feeding of the coal to the retort. During the time that no coal is fed to the retort, the coal in the retort will burn back to the ram and cause it to get hot. In order to prevent this, it is necessary to keep a fresh supply of green coal going to the rams.

When a ram becomes heated due to this stoppage of coal supply, it is first necessary to be sure that the upper ram is feeding coal and then, since the coal already in the retort is probably coked and arched over the lower ram, it is necessary to change the stroke of this ram in

order to put fresh coal into the retort and break up the arch.

This is done by inserting washers on the lower ram push rod so that the ram is brought out as far to the front of the stoker as possible. With the ram in this position, run the stoker for several revolutions and then change the washers so as to move the ram into the retort as far as possible and run the stoker for several revolutions.

When the ram is moved out as far as possible, the green coal has a chance to drop into the retort in front of the ram; thus filling up the retort with green coal. Then the ram is moved in as far as possible which pushes the coal back into the retort and carries along with it any clinker or arch formation.

It may be necessary to repeat this operation several times in stubborn cases but it usually cures the heating of the rams.

Corrosion Affected by Oxygen Content in Water

WHAT IS THE ALLOWABLE oxygen content of zero-hardness boiler feed that will not cause corrosion and how is this limit of content maintained? T. G. F.

A. Oxygen content of 1 c.c. per liter or less in boiler feedwater of zero hardness will not cause corrosion. This is the usual limit of oxygen which the average open heater, when properly operated, leaves in the feedwater.

In order to keep the oxygen below this limit, the open heater should be provided with a live steam connection controlled by a thermostatic valve so that whenever there is an insufficient amount of exhaust steam to maintain the temperature of the feedwater at the boiling point, the live steam valve would open and supply the needed steam. The heater should also be provided with a proper vent which is open to the atmosphere, this vent being vertical and free from horizontal portions which might act as seals when filled with condensate.

In other words, there should be a discharge of vapor at all times from the vent so that the air liberated by the heat may escape to the atmosphere. If this is done, the oxygen content of the feedwater will be below 1 c.c. per liter and we have not encountered any case of corrosion of boilers with such proper operation of the open heater preceding the boiler.

Starting Fire on Traveling Grate Stoker

HOW LONG AFTER new brickwork has been built around a stoker, may the boiler be operated to capacity and how best may the necessary drying be accomplished?

What precautions should be used in starting a fire on a traveling grate stoker? W. G.

A. Fire for operation should not be started on a grate until all of the new brickwork has been dried by a slow fire for from several days to a week.

Before starting the fires on a traveling grate, all grease cups, oil piping and gear cases should be filled with proper lubricants.

To kindle the fire, lower the feed plate, raise the regulating gate and cover the front portion of the grate with a layer of coal and start a fire on top of this coal with wood or other kindling. Admit air to the fire through the first compartment and as the fire begins to burn add additional coal, moving the grate ahead from 6 in. to a foot at a time until the ignition arch is thoroughly heated, then lower the regulating gate to within 6 or 8 in. of the grate. Raise the feed plate into position and fill the hoppers with coal.

Move the stoker slowly at first, admitting sufficient air throughout the first compartment to cause the fuel to burn rapidly. If the fire does not burn rapidly, stop the stoker and keep a small amount of air in the first compartment until the fire works back toward the feed plate, when the stoker can be started again.

Cylinder Wear

WHY IS IT that cylinders of steam engines need to be rebored? Should the piston rest on the bottom of the cylinder or should it be held up by the crosshead?

A. S. G.

A. Cylinders need to be rebored because they wear out of round and lower the position of the piston, hence cause undue wear on the stuffing-box and consequent leakage.

The piston should not be suspended by the stuffing box, which would be the case in a badly worn cylinder of an engine having no slipper at the head end of the cylinder. Large two-cycle horizontal gas engines are provided with such slippers because of the extreme weight of the long, water-filled piston required in this case. A crosshead alone would not sustain the weight of the piston because its weight is applied at a considerable distance from the crosshead.

If a slipper were used, the piston would be carried properly by the crosshead and slipper but such construction is rare in steam engines; the piston should therefore be supported, usually, by the cylinder bore. Use of a slipper requires the addition of a second stuffing-box which complicates the mechanism and introduces greater possibility of steam leakage.

The cylinder will wear much faster when it supports the piston weight than when crosshead and slipper support this weight and tightness against steam leakage is secured by the piston rings. Moreover, in this case, the wear, such as it may be, would be more uniform, retaining the circular form of the cylinder bore.

For these reasons, cylinder wear in vertical engines is more uniform and is less than that in horizontal engines.

IN THERMODYNAMICS, the terms gas and vapor are used to differentiate materials. Thus steam is a vapor while hydrogen is a gas. Sometimes the term permanent gas is used. This latter term was applied many years ago when it was thought that some gases such as hydrogen, oxygen, and nitrogen could not be liquefied.

This is not, of course, true, as we now know because all gases can be liquefied if the temperature is reduced sufficiently. Hydrogen liquefies at —422, nitrogen at —316, oxygen at 296 deg. F. Even air liquefies at —312 deg. F. The only essential difference between a gas and vapor is that the latter liquefies in our ordinary temperature range, while the latter does not. As the liquefying point is neared, the behavior of the vapor differs somewhat from its action when more highly superheated, so that our practical gas formulas apply as a rule to only a comparatively small temperature range.

Editorial Comment

Power Plants Need Cultivation

Power is needed in every modern industrial plant. The more that power is utilized the better will be the conditions for workers, the greater the production and the less the cost per unit produced.

Economists and financial writers are advancing, as the cause of the present industrial situation, many factors, among them overproduction and under consumption. Both these terms are indefinite and may be taken to have various meanings, depending on one's point of view.

If a factory or an industry is producing more than it can sell, one writer will talk of overproduction, spite of the fact that many people might like those goods and might buy them if the price was within their means. The manufacturer will talk of underconsumption, meaning that his product is failing to sell as rapidly and as widely as he feels that it should in view of the people who would like it and could use it. Neither point of view is based on a scientific consideration and analysis of how many people could use the product with greater benefit to themselves than anything else that could be purchased at the same cost.

Since buying, especially for personal use, is based to a large extent on individual inclination, it is unlikely that production and sales will ever be balanced on study of real economic advantages to the purchaser. The other sane alternative is to try to bring the cost of products to a point where they will be within the reach of all consumers who feel that they would like to use such products, rather than to influence purchasers to pay more than they feel able to afford.

Here steps in greater use of power and its saving in labor and overhead cost of production to help solve the problem. But there arises the question, Shall power be purchased or generated by the industrial plant? This is a case where scientific analysis should decide rather than inclination or sales arguments. Each case requires consideration on its own merits and conditions.

Manufacturers are human and prone to be influenced by plausible statements. Facilities are available to every plant engineer to post himself on costs of equipment and operation so that he can place before his executive superior the facts as to comparative costs of operation with purchased and generated power. Often a study of the power and heat requirements of neighboring plants will show an economy by merging facilities into a group plant or by interconnecting the power systems.

Investment cost for a plant looks big to some plant owners. They seem to forget that, if they use power, they will pay the overhead on such an investment somehow, either in the rate paid for purchased power or in the overhead on their own power plants. The central station industry is requiring great amounts of capital for financing its extensions and this is largely secured from owners of industry, who might, if careful analysis were made, find that investment in their own plants would be economy. Where such an analysis, covering present and future requirements, with power used as fully as possible to give best economy in production, shows that purchased power is logical rather than an individual or a group plant, there should be no question about purchasing power.

For individual and group plants to prove their right to continued existence, it is necessary that they utilize modern knowledge and methods so as to bring their economy to a point comparable with that of central stations. Inevitably, comparison of a run down, badly operated industrial plant with the cost of power from an economical modern central station will show to the advantage of the latter. Only by building or rehabilitating a plant to meet the requirements of an industry in the best possible way, can it become an effective competitor of central station power.

To aid in bettering present conditions, every responsible engineer in a plant should study the present and possible uses of power in the industry that he supplies, how economy in the use of power and heat can be bettered, and, with such improved use of energy, the requirements for power and heat supply. Then study the needs of neighbors and compare them. No longer is it sufficient for an engineer in charge of a plant to be satisfied with keeping his plant, whether for generation or utilization of power in good operating condition. He must comprehend, as did the understanding mason who was "helping to build a cathedral," that cost of product is the final test of a manufacturing plant and that whatever he does to help reduce that cost is helping to solve the problems of overproduction and under-consumption in the world's markets.

Now is the time that such analysis is needed. Conditions are favorable for building or rehabilitating plants. That central stations are alive to their opportunities is proved by a recent statement of a great public utility executive that expenditure of his companies for building and rehabilitation during 1930 would be nearly $200,000,000 and that their business for 1930 would be 10 per cent larger than for 1929.

Spite of the tremendous increase of central station power, census returns show a large increase in industrial generating plant capacity during the past 10 yr. If responsible heads of such plants are alive to their opportunities, power use in industry will continue to increase, individual power plants will show increasingly better economies and the growth of industrial plants will continue. Indolence, indifference and timidity never yet won success.

Thrift or Extravagance?

In this day of change, with many new developments and rapidly increasing efficiency, old standards of frugality are as far out of date as the old vertical turbine. To be thrifty often necessitates an apparently extravagant policy because waste, today, goes hand in hand with parsimony.

The pony express, the stage coach and the horse and buggy are as effective as ever but they have been entirely superseded by the telegraph, railroad, automobile and airplane. Today the winds of the seven seas are as effective as in the time of Columbus but sailing ships have disappeared from the world of commerce. These changes have taken place not because the effectiveness of this primitive equipment decreased but because they were superseded by more effective equipment, which, although it costs much more, offered such advantages of speed, capacity and convenience that its use could not be denied.

So it is with power plant equipment. Hand-fired furnaces, batteries of small low-pressure boilers, preservative water treating equipment, early types of prime movers and power transmission systems all answer their purpose as well today as they did 20 or 30 yr. ago, yet these are an expensive luxury that only the most opulent industry can afford. Many times, advantages of replacing them with new modern equipment can be traced directly back to the coal pile and measured in dollars. Other times, the advantages of replacement must be measured in terms of improved service, more consistent operation or decreased floor space which releases valuable property for other uses.

Nor is the advantage of replacement limited to old equipment. With proper maintenance, the useful life of any modern machine should be at least 20 yr., with chances that it might operate indefinitely. When additional boiler capacity is needed, it takes little imagination to see the advisability of scrapping a stoker 6 yr. old in order to replace it with one that will burn 50 or 75 per cent more coal more efficiently and thus save not only coal but the expense of additional boilers.

Bleeder turbines can replace straight condensing units in many places, while the improvements in water rates of modern turbines and engines are sufficient to warrant the expense of scrapping comparatively new machines. The improvement is not so noticeable when compared at the most efficient load but great strides have been made in flattening the water rate curve and giving better light load conditions, which, after all, is the important item because few machines operate for any considerable part of the time at their most efficient point and comparison should be made at the point of normal operation.

No longer is the actual life of a piece of equipment a measure of its usefulness. Obsolescence must be taken into consideration and the length of service based on its economic and not material life. Every single piece of installed equipment should be compared point for point with its modern counterpart and scrapped, if it is found wanting.

Its performance should be judged not by what it is or does in itself but by what it is and does in comparison with a modern machine. Equipment prices are lower than they have been for years and the wide awake engineer cannot afford to pass up the opportunity of improving his plant in a manner that is bound to pay impressively large dividends.

THERE ARE ONLY six general items in a heat balance of an internal combustion engine; they are: useful mechanical energy, jacket loss, exhaust gas loss, incomplete combustion, radiation and friction.

Proper Location of Unit Heaters

One of the most interesting developments in the heating and ventilating field has been the rapid rise to prominence of the unit heater. Like so many other engineering developments, it was a product partly of necessity and partly of the ability of manufacturers to supply it. It has made a place of its own in the heating field without competing to any great extent with the central fan or duct system, which still has a great many applications.

But it is the flexibility of the unit heater that makes it particularly adaptable to certain types of industrial buildings. The manufacturers have done such a good job in the design and construction of the various types of unit heaters that their proper installation and operation are comparatively simple matters. Almost the only real problem in using them lies in the proper location of the various units in a given room.

This problem is ably discussed elsewhere in this issue by Charles L. Hubbard. He shows many typical building layouts and the various arrangements of heaters that can be made to give proper heat and air distribution in them. The unit heater lends itself well to a little experimentation in heating a building. The usual practice is to assume that a theoretically correct layout will probably be modified by unpredictable factors. If it is found that some of the units need to be moved a few feet one way or another to improve air distribution in the room, such changes are not extremely expensive and the equipment can be made to fit the conditions of each particular space.

Automatic control of the units is not difficult and this enormously simplifies the operating problem. It is often found that the unit heater adapts itself especially well to existing systems without much change in piping or electrical circuits. Turbine driven fans on unit heaters often apply with great effectiveness to certain conditions. In short, the chief problem is that of locating the units to fit each set of conditions. Analyses such as Mr. Hubbard's are of great assistance in doing this.

There might be an opportunity for reducing costs of heating still further, in connection with all types of heating equipment and especially with unit heaters, if more information were available on natural air circulation of buildings. Some valuable data have been compiled on the subject by W. C. Randall and it is expected that more work will be done in the future. It would seem that there must be a definite relation between the natural air circulation of a structure and the heat distribution in it for different temperature and wind conditions.

To discover such relations, if they exist, is a refinement of research that will doubtless prove of great value in locating unit heaters. Even without this refinement, however, a great deal can be done, as Mr. Hubbard shows in his article.

AFTER ALL is said and done, we must face the fact that accidents are caused from not being careful enough. A moment spent in making sure may save hours and days in making right. Just train yourself to be careful in everything you do. It's the safe way and the right way. And believe me, brother, it pays.—The Safe Worker.

Power Plant Engineering Developments and News

Socket Wrenches

LINE of detachable socket wrenches for industrial service, designed to provide complete equipment for every variety of work, has recently been announced by J. H. Williams & Co., Buffalo, N. Y. Three separate and distinct patterns of sockets with a full assortment of handles and parts for each are available. Standard pattern with ½-in. square drive includes sockets with double-hex, hex and square openings

FIG. 1. EXTRA HEAVY DUTY WRENCHES, 1-IN. HEX DRIVE, ASSEMBLED IN SET

FIG. 2. HEAVY DUTY PATTERN

FIG. 3. EXTRA HEAVY DUTY PATTERN

FIG. 4. STANDARD PATTERN

up to 1 in. for ordinary needs. Heavy-duty pattern with ¾-in. square drive provides sockets with double-hex openings ⅞ to 1⅛ in. This line is designed for harder service than usual in the ordinary run of work. The third pattern, extra heavy duty, has a 1-in. hex drive and sockets with double-hex openings 1 1/16 to 2⅜ in. This pattern is designed for the hardest and heaviest service.

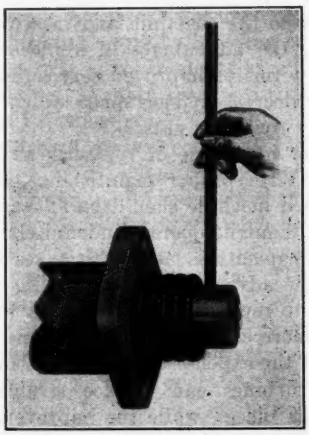
For the convenience of users, these socket wrenches are available in careful selections of the popular sizes of sockets combined with the necessary handles and parts, furnished in a convenient steel box with trays or compartments. All sockets, handles and accessories are chrome-plated over nickel.

Semi-Metallic Packing in Rod Form

CORDEX, a new packing recently placed on the market, is composed of metal particles, asbestos fiber, binder and a specially-prepared lubricant, all encased in a thin shell of viscous material and made up into straight rods 18 in. long. To use it, the packing is wrapped around the rod to be packed, inserted in the stuffing-box and the gland drawn up.

After this is done, the casing of viscous material disrupts and disappears, it is claimed, since the casing is made only strong enough to endure the necessary handling.

Important advantages claimed for Cordex are that it fits any stuffing-box, that there is no waste since it is necessary only to add more turns as the packing wears, leaving the original turns in the box, that it lubricates itself and forms itself into a resilient anti-friction bearing around the rod.

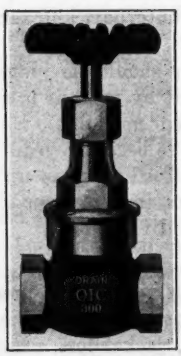


METHOD OF INSERTING CORDEX IN STUFFING-BOX

This packing, a new product of Metalastic, Inc., Union City, N. J., is available in all sizes from 3/16 in. to 1 in., packed in 18-in. lengths in cartons of 5 to 20 lb. Gray seal type is supplied for temperatures up to 500 deg. and Red Seal for temperatures up to 1200 deg.

O. I. C. Drain Valve

DEVELOPED originally for use as a drain valve for water columns and gage glasses on locomotives, the O. I. C. drain valve for steam pressures up to 300 lb.



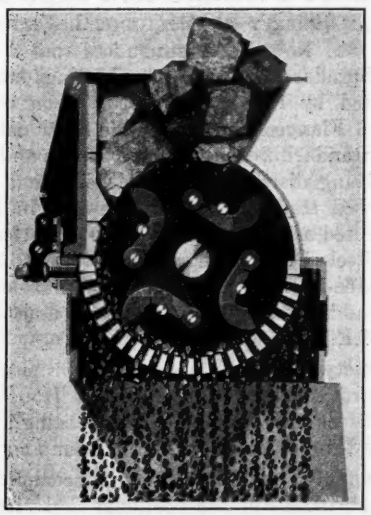
O.I.C. DRAIN VALVE

has recently been placed on the market by the Ohio Injector Co., Wadsworth, Ohio. It is furnished in two sizes: ⅜ in. and ¾ in.

Body and bonnet are made of special valve bronze of high tensile strength, stem is of manganese bronze and removable seat ring and disc are of O. I. C. high nickel bronze. The special form of seating surfaces and the use of the high nickel bronze disc and seat are intended to prevent erosion and give long service with water containing excessive impurities.

Flextooth Crusher

FLEXTOOTH CRUSHER, a slow-speed crusher of the single roll type designed for reducing coal and similar materials to small sizes, has recently been developed by the Jeffrey Mfg. Co., Columbus, Ohio. It is



TEETH OF CRUSHER ARE HELD OUT BY CENTRIFUGAL FORCE

made in sizes from 20 by 12 to 42 by 48 for speeds from 500 r.p.m. to 250 r.p.m. on the larger sizes. Crushing bituminous coal to 2 in., it is designed for capacities from 25 t. to 350 t. per hr; crushing to ¼ in., for 5 t. to 90 t. per hr.

Construction of the crusher is as shown. It is provided with renewable steel crusher teeth, kept in their outward position by centrifugal force. The teeth are designed so that this outward position is maintained at slow speed but if they come in contact with tramp iron or other hard material, the teeth are free to swing back. This design is to protect against breakage. A hinged breaker plate is provided for easy access and large screening area is used to give large capacity of uniform product. Large flywheel pulley is fitted to furnish suitable belt drive direct to the motor pulley.

New Heavy-Current High Voltage Magnetic Switches

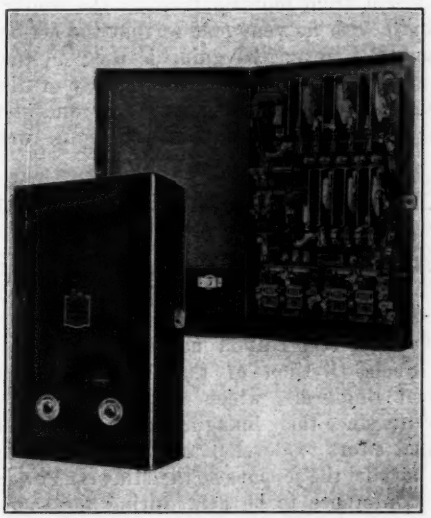
OIL-IMMERSED magnetic switches, CR-7006-T-5, for heavy-current duty in controlling large sizes of motors are announced by General Electric Co., Schenectady, N. Y. The new switches supersede the General Electric CR-7006-T-3, 150-amp. magnetic switch. They consist of a three-pole, 200-amp., oil-immersed contactor, a temperature overload relay, two current transformers and an undervoltage relay all mounted on a suitable floor-mounted framework, which is built with steel front.

Instantaneous undervoltage protection is obtained with one form when used with a drum switch, it is stated, and time delay undervoltage protection is obtained with the other form when used with momentary contact type push-button control.

For standard motors the switches are rated 750 hp. at 2500 v., and 1200 hp. at 4000 v. They have an approximate weight of 525 lb. and require 5½ gal. of oil each. These switches may be used on 6600-v., 750-hp. maximum, by providing 6600-v. current transformers.

Automatic Controller for A. C. Multi-Speed Motors

NEW AUTOMATIC controller for two-speed, consequent pole type (reconnected) squirrel-cage motors has been announced by Cutler-Hammer, Inc., 191 12th St., Milwaukee, Wis. This controller, known as Bulletin 9739, functions to start the motor and to change its speed by reconnecting the motor windings. It is made to provide to thermal overload protection at both



AUTOMATIC CONTROLLER FOR A.C. MULTI-SPEED MOTORS

motor speeds and low-voltage protection. A separate pushbutton master switch with "stop," "low," and "high" buttons is used to provide three-wire remote control.

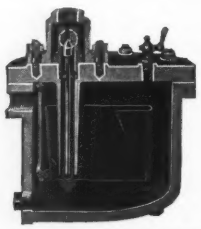
These new controllers are furnished for constant horsepower, constant torque, or variable torque motors. A sequence compelling feature can be furnished which makes it necessary always to start the motor on low speed before bringing it up to high speed.

COOLING WATER used in the cylinder jackets of internal combustion engines serves a dual purpose. It keeps the metal of the cylinder walls from overheating, which would cause distortion and decreased strength, and it also keeps the wall at a temperature sufficiently low, so that lubrication can be maintained.

Intermittent Steam Trap

INTERMITTENT STEAM TRAP for general industrial use, as shown herewith, has recently been placed on the market by Watson & McDaniel Co., Philadelphia, Pa. This trap is designed to discharge only when the open float is filled with condensation. It is supplied in capacities from 1250 to 6500 lb. water an hour at 150 lb. pressure, to drain from 7500 to 39,000 ft. of 1-in. pipe or from 2500 to 13,000 sq. ft. of heating surface.

After condensation is discharged to a predetermined level, maintaining a water seal over the discharge tube, the trap is built to close the discharge valve until the float is filled again. Baffles or vanes are provided on



CROSS-SECTION OF INTERMITTENT STEAM TRAP

the side of the discharge tube to prevent whirlpools from forming when the trap discharges. This is to prevent steam from blowing through the center. The float is built with no vent hole so that the action is instantaneous. A restricted guide is used on the valve stem to guide it and cut down the velocity of discharge to prolong life of seat and stem. Seat and stem and bucket trunnions are of two metals to reduce wear.

Fourth National Fuels Meeting Program

PROGRAM for the Fourth National Fuels Meeting of the A.S.M.E. which will be held in Chicago February 11 to 13, 1931, is rapidly nearing the stage where papers and authors for each session may be announced.

The Fuels Division of the American Society of Mechanical Engineers, which has sponsored these national events since their inauguration in 1927, is making an unusual effort to develop the type of program best fitted to parallel the sessions of the Midwest Power Engineering Conference to be held during the same week. The procedure for the Fourth National Fuels meeting will be somewhat different from that followed at the three previous meetings. Heretofore the meetings have started on Monday morning and have run four days with as high as three simultaneous sessions during some of the periods. The coming meeting will start on Wednesday afternoon and both the Fuels Division and the Chicago Section of the A.S.M.E. which is in charge of all local arrangements, have agreed that there must be no simultaneous sessions.

For the first time in the history of the meetings a parallel convention will operate during two days of the three-day event. Both programs, however, have been so laid out that there will be no conflicting sessions and the engineer interested in both fuels and power can arrange his schedule so that maximum results may be had.

Among the subjects included in the program in its present form are the following, each of which will be discussed by prominent authorities in the fields represented: Developments in Furnace Design, Developments in Pulverized Fuel Firing, Developments in the Small Stoker Field, The Use of Refinery Waste Fuels, The Use of Natural Gas and the Conversion of Coal-Fired Furnaces to Gas, Boiler Efficiencies as Affected by Types of Fuels, Effect of Temperature on Rapidity of Combustion, Heat Absorption as Affected by Furnace Wall Materials, Selection and Coördination of Steam Generating Equipment, Design and Performance of Large Boiler Units, The Boiler Plant of the Future, Changes in Character of Mid-West Coals and Stoker Performances, Air Pollution.

A.S.M.E. Announces Standards for Steel Base Fittings and Pipe Plugs

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th St., New York, announces that a proposed American Standard for Steel Base Fittings has recently been released by Subcommittee No. 3 on Steel Pipe Flanges and Flanged Fittings of the Sectional Committee on the Standardization of Pipe Flanges and Fittings. It is now being distributed for criticism and comment. This proposed standard is not complete in itself but must be treated as a supplement to the American Standard for Steel Pipe Flanges and Flanged Fittings, (A.S.A. B16e-1927). All comments and suggestions should be addressed to C. B. LePage, assistant secretary, A.S.M.E., 29 West 39th St., New York, N. Y.

The Society also announces that a proposed American Standard for Pipe Plugs of Cast Iron, Malleable Iron, Cast Steel of Forged Steel is now being distributed in tentative form to industry for criticism and comment.

This standard, as proposed by Subcommittee No. 2 on Screwed Fittings of the Sectional Committee on the Standardization of Pipe Flanges and Fittings, has the approval of the manufacturers for use in connection with the American Standards for 125-lb. and 250-lb. Cast Iron Screwed Fittings and the American Standard for 150-lb. Malleable Iron Screwed Fittings. The pipe plugs which it covers are intended for use with the fittings included in the two American Standards mentioned. This material is now in tentative form for discussion and all criticisms will be welcomed. These should be addressed to C. B. LePage, at the above address.

NEW YORK SECTION of the American Institute of Electrical Engineers has arranged for the first time this year a course in Effective Speaking. The instructor, Dale Carnegie, will train the engineers of the Section to think on their feet and speak more clearly and confidently in business interviews, it is announced. It is proposed that on each Thursday evening for a period of 14 weeks, each member taking the course will be called upon to stand up and make a two or three minute talk under the supervision of the instructor.

HENSZEY DE-CONCENTRATOR CO., Watertown, Wis., announces the appointment of the Beeson Engineering Co., Ltd., 315 West Ninth St., Los Angeles, Calif., as its sales representatives for that territory.

Professor Elihu Thomson Honored by Electrical Industry

HAILED as one of the world's greatest scientists and engineers in the electrical industry, Prof. Elihu Thomson, director of the Thomson research laboratory of the General Electric Co. at Lynn, Mass., was guest of honor at a testimonial dinner tendered him recently at the New Ocean House in Swampscott, Mass., on the completion of 50 yr. service in the industry.

He was the guest of honor at a dinner given by the Allied Service Clubs of Lynn. Fully 700 neighbors from Swampscott, friends of years' standing, and co-workers in the electrical field were present to cheer him when he was presented with a large silver platter by the allied clubs.

Scores of telegrams were received from all parts of the country and from many foreign countries. President Hoover, former President Coolidge, Thomas A. Edison, Gov. Allen of Massachusetts, Owen D. Young and Gerard Swope, chairman of the board and president of the General Electric Co., respectively, sent their congratulations.

While his friends were paying tribute, the General Electric radio hour was brought to the banquet room and Floyd Gibbons briefly told thousands of listeners of the accomplishments of Prof. Thomson and closed with a strong personal tribute.

President Hoover, in his telegram, said: "I am gratified to learn of the honors being paid you in recognition of your 50th year of distinguished service in the electrical industry and I cordially join in the appreciation of your scientific labors which have so widely benefited mankind. Please accept my hearty congratulations and best wishes for health and every happiness."

Benjamin M. Johnson, president of the Lynn Historical Society, was toastmaster. Dr. E. W. Rice, honorary chairman of the board of General Electric, who at 18 yr. of age was a pupil in Central High School in Philadelphia, when Prof. Thomson, at 23 yr., was a professor and one of his teachers there, paid high tribute to Prof. Thomson as a brilliant teacher and lecturer in science.

Mayor J. Fred Manning of Lynn, Nathan G. Bubier, chairman of the Swampscott board of selectmen, Henry D. Sprague, honorary chairman of the board of the Central National Bank of Lynn, a neighbor of Prof. Thomson's, Dr. Samuel W. Stratton and Dr. Karl Taylor Compton, chairman of the executive committee and president, respectively, of the Massachusetts Institute of Technology, spoke in laudatory terms of the guest of honor. Fred T. Mitchell, president of the Allied Service Clubs, then presented the gift, a silver tray, and introduced Prof. Thomson.

In his address, Prof. Thomson said it was difficult to express his thanks for the generous expressions of friendliness showered upon him and emphasized that the assembly itself was a touching tribute that he will never forget. He spoke of the courage of the members of the Lynn syndicate, which originally brought the industry to that city, Mr. Rice, Silas A. Barton, Henry A. Pevear, the first president; Joseph N. Smith, Benjamin F. Spinney, Patrick A. Lennox, and Charles A. Coffin, and lauded their business acumen, vision and persistence.

He told, briefly, the history of the company from its first combination as the Thomson-Houston Electric Co. to its later consolidation as the General Electric Co. and his remaining in Lynn, for which he formed a deep attachment. He said that it had always been his ambition to work with a large organization, to work on a large scale on applications of science and that with his 50 yr. with the General Electric Co. he had realized that ambition.

Alloys of Iron Research Program

SUMMARY of world progress in the field of iron alloys, advance in which is held to be fundamental for American industry, is the object of a program of research enlisting the coöperation of more than 60 industrial and scientific organizations and corporations of the United States under the leadership of the Engineering Foundation, 29 West 39th St., New York.

A fund of $230,000 to make possible a review of all available literature has been contributed by the coöperating organizations, among which are the American Foundrymen's Association, the Battelle Memorial Institute of Columbus, O., and approximately 50 companies producing or using steel and iron. Universities and technical schools, foreign agencies and bureaus of the United States Government are aiding the project, in which the Engineering Foundation has the active assistance of the American Institute of Mining and Metallurgical Engineers and the American Iron and Steel Institute. The American Society of Mechanical Engineers, American Society of Civil Engineers, and American Institute of Electrical Engineers also are coöperating.

The scope of the investigation, which is described as the most ambitious ever undertaken in this field, was outlined by an advisory committee headed by John Johnston, Director of Research and Technology of the United States Steel Corp. Supervision of the program, which will require 5 yr. for completion, has been delegated to an Iron Alloys Committee, of which Dr. George B. Waterhouse, professor of metallurgy in the Massachusetts Institute of Technology, is chairman.

As its initial task, the Foundation and its coöperating organizations are conducting a critical review of all available literature in English and other languages. Coincident with this review, two lines of original research into iron alloys have been initiated. Others will be taken up later as the need for them is revealed by the critical examination of the extensive literature.

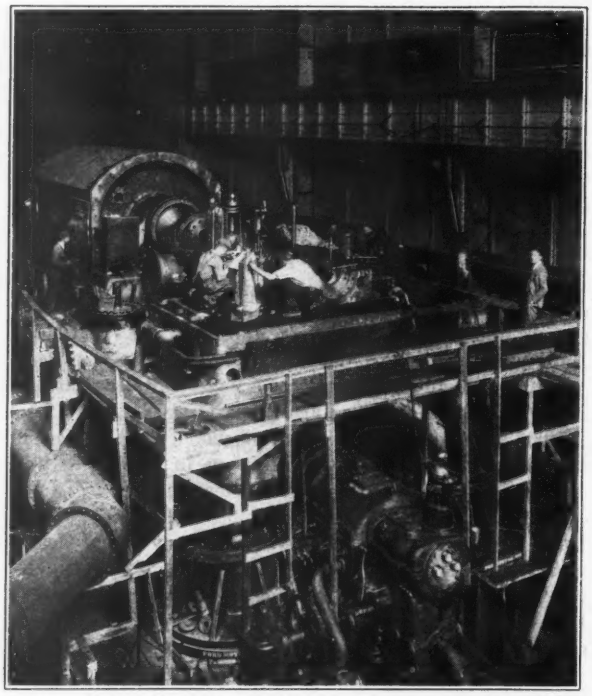
Underlying the plans of the Foundation and its associated bodies, according to the announcement, is the growing necessity for condensed, dependable statements in convenient, classified reference books, of the basic information upon which the future advancement of the iron and steel industry may be built. World competition and increasing demands upon production are expanding the need for research which will keep the United States abreast of progress in the field of iron and steel alloys.

ALLIS-CHALMERS MANUFACTURING CO., Milwaukee, Wis., announces the receipt of order from West Virginia Hydroelectric Co., a subsidiary of the Union Carbide & Carbon Corp., covering 10 large power transformers amounting to approximately $500,000. This is the second order recently received by Allis-Chalmers from this company, the previous order covering two welded steel surface condensers for use with 30,000-kv-a. steam turbines.

Testing Largest Industrial Turbine for Ford Motor Co.

ASSEMBLY of the 1200-lb., 1800-r.p.m. high-pressure element of the 110,000-kw., vertical-compound turbine-generator for the Ford Motor Co. at the Schenectady Works of the General Electric Co. for factory tests is shown herewith. The double-flow, low-pressure turbine and generator are directly beneath the high-pressure turbine and generator.

Besides being the largest industrial turbine-generator, the largest vertical-compound machine and the largest turbine-generator to operate on 1200 lb. steam pressure, it is also stated to be the most compact unit yet



ASSEMBLING 110,000-KW., 1200-LB. VERTICAL COMPOUND UNIT FOR TEST

built. Two older generating units, rated 12,500 kw. each, will be moved out to make room for the new machine which will occupy approximately the same amount of floor space.

General Water Treatment Corporation Formed

ORGANIZATION of General Water Treatment Corp. under Delaware laws as a holding company to merge the interests of the Permutit Co., New York, and the Ward-Love Pump Corp., Chicago, is announced in a letter to stockholders of the Permutit Co. from W. Spencer Robertson, president.

The companies in the merger have combined assets of more than $4,000,000. Mr. Robertson will be president of the corporation and Francis N. Bard, president of the Ward-Love Pump Corp., will be chairman of the board of directors. Other board members will be Vincent Bendix, Harry M. Durning, William M. Flook and Kenneth B. Schley.

The Permutit Co. has plants at Brooklyn, New York, and Birmingham, New Jersey. In addition to its executive offices in New York City it has 23 sales offices throughout the United States. The Ward-Love Pump Corp. has two plants located at Rockford, Ill., its executive offices being located at Chicago, Ill., and enjoys facilities for the distribution of its products through the Crane Co.

News Notes

CONTRACT from the West Virginia Hydroelectric Co., a subsidiary of the Union Carbide & Carbon Corp., amounting to approximately half a million dollars and covering two pulverized coal fired boiler units, to be installed at Boncar, W. Va., has been awarded to Combustion Engineering Corp., it is announced. The equipment includes 2 Walsh-Weidner single pass, sectional header boilers, interdeck Elesco superheaters, boiler and furnace settings, fin tube walls for the four sides of each furnace and plain tube water screens for the furnace bottoms, pulverized fuel burning equipment, duct work and supporting steel.

This is to be a mine-mouth plant, utilizing coal taken direct from the tipples. Because of the low cost of the fuel, no heat recovery equipment was justified.

The boilers are of high single-pass construction, to provide for the most effective use of natural draft, and are designed for 488 lb. pressure, with an operating pressure of 450 lb., and a total superheated steam temperature of 750 deg. F. Each boiler will have 31,500 sq. ft. of heating surface with an additional 4140 sq. ft. per unit provided by the fin tube walls and water screen. The units are guaranteed for a continuous capacity of 287,500 lb. of steam per hr., and a maximum capacity of 325,000 lb. of steam per hr. Ford, Bacon & Davis are the consulting engineers.

PALMER-BEE Co., Detroit, Mich., announces the opening of the following district offices, in charge of the district managers noted: Buffalo, N. Y., Room 333, Ellicott Sq. Bldg., E. C. Jeremias; Pittsburgh, Pa., Room 508, Farmers Bank Bldg., 5th Ave. and Wood St., C. E. Musselman; Cleveland, O., Room 1056, Rockefeller Bldg., F. B. Barkwill; Southern Office, Room 1210, Reynolds Bldg., Winston-Salem, N. C., E. S. Davidson; Philadelphia, Pa., Bulletin Bldg., S. T. Transeau.

ANNOUNCEMENT is made that Worthington Pump & Machy. Corp., 2 Park Ave., New York, has acquired the Gilman Manufacturing Co., East Boston, Mass.

RESIGNATION of William A. Reece as president and managing director of the General Electric, S. A., of Argentina, to become the managing director of the Anglo-Argentine Electricidade, has been announced by Walter J. Edmonds, vice-president of the International General Electric Co. Anglo-Argentine Electricidade consists of a large group of public utility properties in the Argentine in which the American and Foreign Power Co. has a substantial financial interest.

Charles Clark Batchelder succeeds Mr. Reece in the General Electric, S. A., of Argentina organization, being appointed vice-president and general manager and chairman of the executive committee.

Appointment of Heman Greenwood as vice-president of the International General Electric Co., Inc., with headquarters in Rio de Janeiro, Brazil, in charge of the company's interests in Brazil and the Argentine, has also been announced by Mr. Edmonds.

Mr. Reece, born in New Zealand, was graduated from Cornell University in 1907. He then entered test at Schenectady and in the following year was transferred to the foreign department. Panama Canal work occupied much of his time in the following years. In 1915 he became managing director for the Cia General Electric Sudamerica and in 1926, when the General Electric, S. A., took over the Argentine business, Mr. Reece was made president and managing director of the newly formed organization.

Mr. Batchelder was graduated from Purdue in 1905 and received his master degree from Union College in 1907. He entered General Electric test in 1905 and was transferred in 1907 to the power and mining department. In 1916 he was sent to Argentine as engineer, and in 1926, when General Electric, S. A., was organized he became chief engineer and a director.

Mr. Greenwood, graduated from the University of California in 1914, was chief instructor in mechanical engineering at Hunan Polytechnic Institute, Changsha, China, in 1917 and 1918. In the following year, associated with the Pelton Water Wheel Co., he went to Brazil. He joined the General Electric foreign branch in 1925, when he was made vice-president and general manager of General Electric, S. A., of Brazil.

ANNOUNCEMENT is made by the Hartford Steam Boiler Inspection and Insurance Co., Hartford, Conn., that Thomas B. Richardson joined the home office engineering department on October 6 as chief engineer of the turbine and engine division. Mr. Richardson is a graduate of the Alabama Polytechnic Institute. He joined the turbine department of the General Electric Co. in 1910 as an erector and was given increasing responsible charge of the installation, operation, and inspection of many large units. For the past 2 yr., he has been associated with the management of a utility plant in Florida.

LECOURTENAY Co., Newark, N. J., announces the appointment of F. J. Moran as Philadelphia district manager with offices in the Witherspoon Building.

IT IS EXPECTED that a saving of one-half the fuel consumption will be made by remodeling of ships for the Baltimore Mail Steamship Co. Five vessels, 11,773 t. dead weight displacement each built in 1919 and 1920 for the Shipping Board are to be lengthened, bow and stern lines modified and equipped with compound turbines having double reduction gearing to give a propeller speed of 95 r.p.m. and boat speed of 16 knots per hour. Units will be 9500 hp., taking steam at 250 lb. and 150 deg. superheat and exhausting at 28½ in. vacuum. They will be furnished by De Laval Steam Turbine Co., Trenton, N. J.

HEATING DIVISION of the Wickes Boiler Co., Saginaw, Mich., announces the appointment of Chas. A. Carpenter, 1124 Park Building, Pittsburgh, Pa., as district representative for L-0 steel heating boilers.

BEGINNING November 1, 1930, the entire line of Gredag Lubricants manufactured by the Acheson Graphite Corp., a unit of the Union Carbide & Carbon Corp. will be distributed and sold by the Carbon Sales Division of National Carbon Co., Inc., with headquarters at Cleveland, Ohio. Sales and technical service on all these lubricants will be available at the branch offices and service plants of the Carbon Sales Division located in New York City, Pittsburgh, Birmingham, Chicago and San Francisco.

HENSZEY DE-CONCENTRATOR Co., Watertown, Wis., announces that H. P. Rodgers & Co., 528 Leader Building, Cleveland, Ohio, has been appointed district sales representatives for the Cleveland territory.

AMERICAN HOIST & DERRICK Co., St. Paul, Minn., announces the removal of its Dayton office to Indianapolis, Ind. The Dayton Office at 254 Fourth Street Arcade has been closed and a new office opened in Indianapolis at 703 New City Trust Building. I. R. Bailey and Wm. M. Schoen, who has been stationed at Indianapolis for many years, will be at the new office. J. T. Conners, the Thew Shovel Co.'s district manager in Detroit for a number of years, has joined the company's sales force.

EFFECTIVE SEPTEMBER 15, B. L. Donahue became manager of the Buffalo district office of Cutler-Hammer, Inc., Milwaukee, Wis., succeeding B. A. Hansen, who has resigned. Mr. Donahue is a graduate of Penn State College, class of '20, and holds the degree of B. S. in electrical engineering. He is a member of the Association of Iron and Steel Electrical Engineers and of Sigma Tau Engineering Fraternity.

R. C. GEPPERT, Council Bluffs, Iowa, has been made general superintendent of the Nebraska Power Co., Roy Page, vice-president and general manager of the company, announced recently. Mr. Geppert was formerly assistant general superintendent and will now be in supervision of merchandise, transportation, accident prevention and claim departments with charge of the Council Bluffs operation of the Citizens Power & Light Co.

LINCOLN ELECTRIC Co., Cleveland, O., announces a competition for papers on utilizing arc welding in construction work. It is open to everybody except employes of the company, the closing date to be Oct. 1, 1931. Forty-one prizes will be awarded ranging from $7500 for first to $100 for the 7th to the 41st. Details of rules can be obtained from the company.

Books and Catalogs

AMERICAN SOCIETY for Testing Materials has issued a special reprint pamphlet covering the testing of electrical insulating materials. This pamphlet contains all of the methods of testing insulating materials prepared by the Committee on Electrical Insulating Materials, also the annual report of the committee, thus giving an idea of the various projects before it.

In 192 pages is provided a handy reference publication for persons interested in the most recent methods of testing insulating materials, available at the price of $1.25 for single copies.

CUB PORTABLE CONVEYOR of the Link-Belt Co., Chicago, is described in its folder No. 1248 and the uses for various purposes are illustrated.

THE CATHEAD TURBINAIR for air or steam drive as used for winch service in construction, mining or general service is described in Bulletin 76-L of the Sullivan Machinery Co., 400 No. Michigan Ave., Chicago, Ill. The cathead has a 7½-hp. motor and is designed to be bolted to a 12 by 12-in. beam or post for operation in either horizontal or vertical position.

ROTATOR rock drill, L-6, a one-man drill weighing 58 lb. for all-around service, is described and its uses illustrated in Bulletin 87-D of the Sullivan Machinery Co., 400 No. Michigan Ave., Chicago, Ill. The machine is suited for mounting on a column or on a tripod as well as for hand support and manipulation.

TURBINAIR portable hoists of 3 and 7½ hp. in single-drum type and 7½ hp. in double-drum type, are shown in Bulletin 76-M of the Sullivan Machinery Co., 400 No. Michigan Ave., Chicago, Ill. Applications for construction, mining, car and materials moving are illustrated.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly at Chicago, Ill., for October, 1930.

State of Illinois, } ss.
County of Cook, }

Before me, a Notary in and for the State and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
Madge W. Rice, Wilmette, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.
R. E. Turner, Chicago, Ill.
A. W. Kramer, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustees or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

TECHNICAL PUBLISHING CO.,
CHAS. SANFORD CLARKE, Secy.

Sworn to and subscribed before me this 4th day of October, 1930.

[Seal.] EDDIE H. KAHL,
Notary Public.

(My commission expires March 20, 1932.)

Power Plant Construction News

Conn., New Britain—The Southern New England Ice Corporation, New Britain, is considering the construction of a new artificial ice-manufacturing plant on Corbin Place, to cost over $100,000, with equipment.

Ind., Butlerville—The State Department of Institutions, Indianapolis, is considering the construction of a steam power plant at the State Home for Feeble Minded, Butlerville, to cost about $45,000. Orlando B. Little, 307 North Illinois Street, Indianapolis, is architect.

Ind., Hammond—The Hammond Lead Products Co., 1200 Standard Avenue, plans installation of electric power equipment in a proposed new plant unit, to cost about $100,000.

Ind., Indianapolis—The Link-Belt Co., South Belmont Avenue, has approved plans for the installation of a pulverized coal system at local Ewart plant, estimated to cost $125,000.

Ind., New Albany—The Hopkins Fertilizer Co., New Albany, plans installation of electric power equipment in connection with proposed rebuilding of portion of commercial fertilizer works recently destroyed by fire with loss reported in excess of $150,000. Company is a subsidiary of the Davison Chemical Co., Garrett Building, Baltimore, Md.

Iowa, Denison—The City Council is planning the installation of a Diesel engine unit and auxiliary equipment at municipal electric light and power plant. W. E. Schwob, Iowa City, Iowa, is engineer.

Mass., Natick—John A. Hill, 90 Pond Street, Natick, has plans nearing completion for a one-story ice-manufacturing plant to cost about $60,000, with equipment. C. Charles Coneby, 1580 Ansel Road, Cleveland, Ohio, is engineer.

Md., Baltimore—The Standard Oil Co. of New Jersey, 26 Broadway, New York, has plans for a new power plant at oil storage and distributing plant at 3505-25 Boston Street, Baltimore, to cost about $35,000, with equipment.

Mich., Detroit—Parke, Davis & Co., Joseph Campau Avenue, Detroit, has plans under way for a one-story addition to power plant at drug and chemical factory, reported to cost over $50,000, with equipment. Smith, Hinchman & Grylls, Marquette Building, Detroit, are engineers.

Mich., Selfridge Field—The Constructing Quartermaster, United States Army, Selfridge Field, will receive bids until Oct. 23, for one 200,000-gal. steel tank on a 75-ft. trestle, as per Circular 3.

Mich., Wyandotte—The City Council will take bids early in November for proposed municipal electric light and power plant on the Van Alstyne Boulevard, to cost about $300,000. The Froehlich & Emery Engineering Co., Second National Bank Building, Toledo, Ohio, is engineer.

Minn., Cloquet—Berst, Foster & Dixfield Co., Cloquet, has approved plans for the construction of a steam-operated electric power at local woodworking factory, to cost close to $100,000, with equipment. Contract for superstructure has been let to the James Leck Co., 211 South Eleventh Street, Minneapolis, Minn.

Minn., Northfield—The Common Council has preliminary plans under way for a municipal electric light and power plant. Estimates of cost will be made in the near future. The Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer.

Mo., St. Louis—The Commonwealth Utilities Corporation, 506 Olive Street, is said to have plans under way for a high-pressure pumping plant, in connection with an expansion and improvement program in waterworks, entire project to cost over $1,000,000. Water purification equipment will also be installed.

Mont., Polson—The Rocky Mountain Power Co., Helena, Mont., has begun the construction of camp buildings, including machine shop, bunk houses, commissary building and other units, preliminary to the construction of proposed new hydroelectric generating plant on the Flathead River, near Polson, entire project reported to cost more than $10,000,000.

Neb., Hastings—The Municipal Water & Light Department has approved plans for an addition to electric light and water plant to cost about $35,000, with equipment.

Neb., Wymore—The Gage County Electric Corporation, Beatrice, Neb., is said to be considering construction of a new steam-operated electric power plant in the vicinity of Wymore. Transmission lines will be extended. Estimates of cost have not been announced.

N. D., Williston—The Great Northern Railway Co., Railroad Building, St. Paul, Minn., is said to be planning early work on superstructure for new steam-operated electric power plant at Williston, to cost over $100,000, with equipment. T. D. McMahon, address noted, is company architect.

N. H., Concord—The Boston & Maine Railroad, North Station, Boston, Mass., plans installation of electric power equipment in connection with an expansion and improvement program at car repair shops at Concord, N. H., entire project reported to cost more than $250,000.

N. J., Old Bridge—Anheuser-Busch, Inc., 721 Pestalozzi Street, St. Louis, Mo., plans installation of electric power equipment in proposed new yeast manufacturing plant on tract of land at Old Bridge, now being acquired, entire project to cost over $500,000. A boiler house will be built.

N. J., Skillman—The Department of Institutions and Agencies, State Office Building, Trenton, has approved plans for the construction of a two-story and basement power plant at institution at Skillman, 35x88 ft., to cost about $86,000, with equipment. The Division of Architecture and Construction, address noted, is architect and engineer in charge.

N. J., Trenton—The Department of Institutions and Agencies, State Office Building, has asked bids on general contract for a new power house at the local state prison. The Division of Architecture and Construction, address noted, is architect and engineer in charge.

N. Y., Auburn—The State Department of Public Works, Albany, has authorized plans for a new power plant at Auburn Prison, to cost about $450,000. Electric power equipment will also be installed in a new machine shop and trades building at the institution to cost about $400,000. The State Department of Architecture, Albany, is in charge.

N. Y., Buffalo—The Buffalo Foundry & Machine Co., 1543 Fillmore Street, has filed plans for a one-story boiler plant at mechanical works.

Pa., Monaca—The Pittsburgh & Lake Erie Railroad Co., Pittsburgh, Pa., plans installation of electric power equipment at proposed river-rail terminal on the Ohio River, near Monaca, with material-handling and other equipment, entire project to cost about $500,000.

Pa., Munhall—The Union Railroad Co., Carnegie Building, Pittsburgh, plans construction of an automatic coaling station with storage and distributing facilities at Munhall, including electric-operated cinder disposal plant, to cost more than $70,000.

Pa., Philadelphia—The Philadelphia Suburban Water Co., Jenkintown, has arranged for a bond issue of $1,800,000, portion of proceeds to be used for extensions and improvements in water plants and systems, including reservoir development at Crum Creek, now under way.

S. C., Aiken City—The City Council is considering the installation of Diesel engine units and accessory equipment for service at the municipal pumping station. Estimates of cost will soon be made.

S. D., Lake Preston—The Union Public Service Co., Pioneer Building, St. Paul, Minn., will proceed with superstructure for a new one-story power plant at Lake Preston, reported to cost about $30,000, with equipment.

Texas, San Antonio—The Central Power & Light Co., San Antonio, is said to have plans maturing for a hydroelectric power development on the Quadalupe River, DeWitt and Victoria Counties, reported to cost over $1,000,000, including transmission lines. Application for permission has been made to the Federal Power Commission, Washington, D. C.

W. Va., Charleston—The Appalachian Electric Power Co., Charleston, is making a review before the Federal Power Commission, Washington, D. C., for a license for proposed new hydroelectric power plant on the New River, entire project reported to cost over $1,000,000, with transmission system.

W. Va., Clarksburg—The Weirton Steel Co., Wierton, W. Va., is said to be planning the electrification of its tin plate mill at Clarksburg, estimated to cost more than $150,000.

W. Va., Logan—The Gulf Refining Co., Frick Annex, Pittsburgh, Pa., plans installation of electric power equipment in proposed oil storage and distributing plant at Logan, entire project reported to cost about $100,000.